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The Unwarranted Criticisms of the Plans for Additional Water for New York.

In response to a resolution of the New York State Senate, introduced by Senator Saxe, the State Water Commission has transmitted to the Senate its papers and other information relating to the proposed additional water supply for the City of New York, including a report by the Commission's engineer, Mr. Myron S. Falk. There has therefore been made public prior to the decision of the Commission itself, all data, including the report of its engineer, on which it is to base its own conclusions. It may perhaps be considered somewhat premature to discuss, prior to the appearance of the report of the Commission, so important a document as the official statement of its engineer but the pressing urgency of an additional supply of water to the City of New York is a sufficient justification for such a proceeding.

The State Water Commission is a body occupying pre-eminently a position of a judicial character in relation to any proposed plan of public water supply which may come before it. Its functions are, broadly, to determine whether the needs of any municipality making application for its approval justify in a general way the plan of relief proposed, and in case any plan is approved to couple with that authorization such measures as will give sufficient and reasonable protection to the interests of all parties affected in the district from which it is proposed to draw a public water supply. It goes without saying that the attitude of the engineer of the State Commission should also be markedly fair and impartial in order to conform with the judicial character of the Commission to which he acts as technical advisor. It is somewhat unfortunate, therefore, that the impression received from a perusal of this report of the engineer of the State Commission is one of hostility to the Board of Water Supply of New York and its plan for the relief of the city in its present extremity. Throughout the entire report, the tone of the engineer is one of extreme criticism of almost every main feature of the proposed plan, and at one point he even goes so far as to intimate that the engineering staff of the Board of Water Supply is exaggerating the needs of the city and playing the part of "certain persons now interested and favoring the new construction." This is a gratuitous reflection on the good faith of the experienced engineers serving the Board of Water Supply for which no justification exists.

The engineer of the State Commission raises three main objections to granting the application made by the Board of Water Supply for utilizing the four watersheds it desires in the Catskill Mountain region. These objections are practically the failure of the city to reduce waste, its failure to agitate successfully for the repeal of the statutes which exclude it from entering Dutchess and Suffolk Counties for the water which they afford, and its failure to make efforts to secure such interstate water as Ten Mile River and those of the Delaware River. He also seems to intimate that the Croton is capable of yielding a larger supply than it is ordinarily credited with, although he does not make that specific statement.

These objections have all been so thoroughly discussed and shown to be absolutely without substance in the public hearings before the State Water Commission that it seems worse than superfluous to hark back to them at this time. It has been shown over and over again with such absolute conclusiveness that the exaggerated ideas of waste of water in New York City, set forth by some objectors to an additional water supply, are groundless, that it is surprising to find any professional official of such a body as the State Water Commission seriously using this argument against the plans of the Board of Water Supply. The preventable waste in the city of New York is small for such a large city; indeed, it is a safe statement that no large city in the United States east of the Mississippi River has so small a waste of public water as New York. There is not the least reason to suppose that the most stringent and effective measures to prevent the waste of its water could by any possibility give it any sensible relief in the present juncture.

The claim that the City of New York should devote its time and energies to securing a repeal of the statutes excluding it from sources of water supply in Dutchess and Suffolk Counties instead of seeking the urgently needed water where it can be found is unworthy of consideration. The business for which the Board of Water Supply has been created is to seek the additional water supply so much needed from available sources and not from those from which the city is excluded by legislation. Both of the prohibitory statutes should be repealed, for there never was any substantial reason for the enactment of either. There is, however, this to be remembered, that even the Burr-Hering-Freeman commission never advised the development of the Dutchess County waters prior to the securing of the Esopus and Rondout Creeks for an additional supply. That Commission advised taking a relatively small quantity of Fishkill Creek water on account of its early availability to relieve present needs, but it distinctly recommended securing the great bulk of the Dutchess County waters only after those of the Catskill Mountain region had been secured, and that plan ought to be adhered to now. That Commission showed that the waters of Fishkill and Wappinger Creeks and of the Jansenkill are all too hard to be used until they can be mingled with proportionately large volumes of the soft and pure waters of the Catskills. These features of the plan now proposed by the Board of Water Supply are so sensible and judicious and so eminently conducive to the welfare of the city that it is scarcely possible the State Water Commission will not so recognize them.

The position which the engineer of the State Water Commission has taken with reference to the interstate waters of Ten Mile River and of the Delaware River is even more remarkable than that regarding the sources of supply excluded by statute. This whole question of New York resorting to interstate sources for its relief has been examined many times and discussed by the legal advisers of the city. Such cases are already in litigation in different parts of the country and have been for years and the present prospect is that they will be in litigation for years to come. The proposition that the City of New York in the present condition of its urgent need for more water at the earliest possible date should so direct its efforts as to involve itself in years of profitless litigation, and then probably fail to secure the sources in question, would be worse than folly, and yet the Engineer of the State Commission soberly recommended such a procedure.

There is a feature of the engineer's report which from one point of view is assuring, though reached rather inconsistently. He argues in a number of different ways as outlined above that the city is really not in such urgent need of additional water after all, and yet comes to the conclusion that in consequence of the waste of time by the city in failing to agitate for either interstate sources or sources excluded by statute, on the whole it is probably best to go immediately to the Catskills for the Esopus supply; the while that single source is capable of yielding only 255 million gallons per day the city should be authorized to build a 500 million gallon aqueduct to carry it! He is of opinion that in some way the other half of the aqueduct capacity may be made available at some indefinite future period if it should be needed.

There has been too much time lost already in fruitless and more or less irrelevant debating on this great project so urgently needed for the relief of the city. The State Commission should proceed at once to grant the application of the Board of Water Supply, at least for the Esopus, Rondout and Catskill Creeks. If there is any serious question about the excessive damages involved in the taking of Schoharie Creek that can be left for future consideration, but the other three sources named should be made available to the city at once.

The Reclassification of Excavation.

For a number of weeks this journal has been in possession of a decision of the United States Circuit Court, Ft. Smith Division, in a case involving the reclassification of material on a railroad contract. It was an equity suit by the Fruin-Bambrick Construction Co. against the Ft. Smith & Western Ry. Co. to recover payment for work done but refused, the court decided, on account of the error of the chief engineer of the railroad in making an incorrect reclassification of certain excavation. While such an opinion is not a pleasant subject to discuss in an engineering publication, it seems only just to the contracting interests of the country, which deserve fair play as much as the parties engaging engineers, to make a few comments concerning it. The contract in question was for the construction of 120 miles of railway in Indian Territory and Oklahoma. The work of grading was done under the direction of the late Frederick W. Bond, acting as the railroad company's chief engineer, and before his death the grading was finished, the classification and estimates had all been made by the resident engineers, and the records were on file in the engineering headquarters. Copies of them had also been furnished to the contractor, but had not been submitted as "final" estimates. Mr. Bond's successor set aside the classification on three sections of the road and made estimates the court described as "dishonest and grossly erroneous and unjust" which were based on an examination characterized as superficial.

The contract between the two parties, which the court stated was badly drawn and indefinite in some respects, calling for care in its construction, read: "The decision of the chief engineer shall be final and conclusive on any dispute which may arise between the parties to this agreement relative to or touching the same; and each of said parties does hereby waive any right of action or other remedy, in law or otherwise, by virtue of said covenants, so that the decision of said engineer shall, in the nature of an award, be final and conclusive on the rights and claims of said parties." Such a stipulation will be enforced in the federal courts except in case the engineer's decision was based on collusion or fraud, or was due to gross errors. The contractor claimed gross and fraudulent error in the reclassification of a large amount of blue shale excavation. It was originally classified as solid rock under a contract clause reading: "Solid rock shall comprise, first, rock in solid beds or masses, in its original or stratified position; second, boulders or detached masses of rock exceeding one cubic yard, and all other material which, in the judgment of the engineer, cannot be moved without being blasted." On the work in question the top 2 ft. of excavation was soil and loose gravel. Under these were 2 ft. of shale that could be removed with a plow, and below that shale which had to be blasted. When it was discovered, the resident engineer's attention was called to it and he in turn discussed it with the division engineer, all agreeing that the material should be classified as rock. Their judgment was afterward confirmed by a personal inspection made by Mr. Bond. The material was removed with powder and dynamite, and Mr. Bond assured the contractor that the section should be classified as 90 per cent. solid rock, 5 per cent. loose rock and 5 per cent. earth.

After Mr. Bond's death an engineer succeeded him who manifestly not only failed to give proper consideration to the judicial functions he had to discharge under the terms of the contract, but in his zeal to serve the railway's president actually misled the latter into assuming a position which, as a lawyer, he would know was untenable. In order to justify a reclassification of materials it is necessary to show that the construction was either done or could have been done by an easier method than that of its class. In this case there was no question that the excavation was made with blasting, so in order to justify a reclassification the ground was examined. For the purpose a number of steps one to four feet deep were cut in the sides of the excavations at intervals, and after standing during a winter they were examined by a consulting engineer. The contractor was not advised that these test cuts were being excavated, although, the court asserts, "common fairness and a decent regard for the rights of the construction company required a totally different procedure." The consulting engineer was put on the witness stand, where he was "trapped by counsel in the cross-examination by the production of the record in another case in which he, as an expert, had, upon similar facts, given an expert opinion directly the reverse of his opinion in this case." On the contractor's side the evidence was overwhelming that the blue shale of this region should be and was classified as solid rock when excavated under conditions like those on this road, but after expose for a few months it would disintegrate so much that its original condition could not be estimated. Mr. J. F. Hinckley, chief engineer of the Frisco System, who was one of the engineers called upon to testify, stated that such shale when exposed for four months in the sides of an excavation made by blasting would be in such a condition as to defy proper classification. In his opinion the right way to make a classification in such materials was to have a man on the work in whose judgment reliance could be made, and then stick to his decision unless both parties demanded a reclassification.

The interest in this case centers about the classification of the shale as solid rock. An attempt was made, as is always done in disputes of this sort, to confuse the court by insisting that the material which was blasted was not rock but "indurated clay," but this assertion was very properly swept aside by the court, which said: "It made no difference, under the contract in suit, whether the material was indurated clay, or shale, or any other material. That was not the test, and it might be that it could have been removed by a pick, and still, in practical railroad construction, should have been classed, under this contract, as solid rock." This is a matter mentioned a number of times in this journal, and brings up the old query concerning the nomenclature of excavation. Why should the terms rock, loose rock and earth be employed in designating classes of excavation, when there may be no earth in earth excavation, no loose rock in loose rock excavation, and no solid rock in solid rock excavation, as generally classified according to the working difficulties of the materials? Much confusion and many dollars of legal expenses will be saved if excavation is classified as, 1, material that can be handled best by pick and shovel, 2, material that can be handled best by plowing with a four-horse plow, and 3, material that can be best excavated by loosening it first by blasting. In such a classification, or its equivalent, no mention is made of rock, earth or any other kind of material. Were such a classification employed there might be honest differences of opinion concerning the need of plowing or blasting, but a contract written in such terms would make the chief engineer insist on proper classification as the work progressed and the mere fact that the work was done in a certain way would, in the absence of written objections by the engineer to that way, be pretty fair evidence that this method should determine the classification. The old system of classification causes needless controversy.

The Yield of Driven Wells.

It is not improbable that engineers fail to appreciate the value of the methods of investigating subsurface water which Prof. C. S. Slichter has been developing in connection with his determinations of the rate of movement of such water. No other explanation can be given of the neglect to utilize them in ascertaining the probable drainage conditions in proposed excavations or the permeability of material on which it is intended to construct dikes. For instance, an investigation by this system of the site on which it has been proposed to construct the Gatun dam of the lock canal at the Isthmus of Panama would be very appropriate at the present time. In heavy excavations in water-bearing material the system would furnish useful indications of the probable amount of pumping and bailing necessary; all contractors know that such information is not furnished by the height of the water table, for very often a high ground-water level occurs in dense material easily kept dry when trenches are opened. The investigations are easily made and the methods have been described so often in engineering papers and the publications of the U. S. Geological Survey that a description of their details is unnecessary here.

Some of the facts ascertained by experience and experiment since the first measurements of underflow were made electrically in Western Kansas in 1901, go a long way toward increasing the available information concerning the yield of wells. Readers of German engineering literature have theoretical discussions galore at their command, but it is safe to say that outside of the remarkable experiments of the late J. C. Hoardley (Eng. Record, Dec. 4, 11, 18 and 25, 1884) there have never been gathered experimental data approaching in value those obtained during the progress of the work of the Geological Survey. Not only have repeated measurements been made of the percolation of water in natural beds of sand and gravel of many kinds, but laboratory investigations have been conducted which determine many of the disputed factors in the phenomena of underground waters. These experiments were made by vertical and horizontal tanks fitted with electrical testing apparatus by which the flow of water vertically and horizontally could be measured with considerable precision, and care was taken to prevent the clogging of the beds of sand by organic growths such as form in filter beds, small amounts of formalin being added to the applied water for this purpose. The investigations with the horizontal tanks demonstrated very clearly that the central thread of water in each capillary pore of the soil moves faster than the water in contact with the walls of the pore, as might be expected. It was also found that the electrolyte which is injected into the soil in order to carry on the measurements electrically diffuses very slightly and its motion is almost exclusively that of the natural flow of the ground water. The experiments with the vertical tank indicated, however, that heavy electrolytes, such as common lye, sink downward much faster than lighter ones like sal ammoniac; in one test in which the ground water had no horizontal movement the electrolyte sank downward about 3 ft., although it had no sidewise diffusion that could be detected at test points only 6 in. from the vertical line of application of the charge. These investigations also showed that the measurements of ground-water flow made in this manner are probably correct to within 10 per cent.

Although the Slichter method will doubtless find applications for various engineering purposes entirely distinct from that for which it was developed, it is probable that the determination of what may be called the specific capacity of wells will prove one of its most valuable uses. Since the electrical method of testing the flow of ground water has been introduced, it has become apparent that the discharge from a tubular well depends upon certain definite factors, and that the uncertainty which has enveloped the subject in the past has been largely due to a failure to record all of these factors, thereby rendering impossible any deduction of general laws from the observed data. It is now customary in the work of the Geological Survey to speak of the specific capacity of wells, a useful term meaning the amount of water furnished under a standard unit head or the amount furnished under a unit lowering of the surface of the water in the well by pumping. Taking the unit of yield as a cubic foot per second and measuring the head in feet of water, the specific capacity of any well is found by dividing the number of second-feet by the hydraulic head. This specific capacity is a factor by which one well can be compared intelligently with another; as a rule, the water-bearing material is fairly uniform in a given locality, and after the specific capacity of a few wells has been ascertained it is possible to foretell with considerable certainty what will be the yield of properly sunk wells in the same locality. It should be borne in mind that the many cases where this uniformity is observed are never recorded, but that the exceptional cases where wells in the same vicinity have different capacities are always the subject of comment, and for this reason receive a prominence that their numbers do not warrant.

In a general way it may be stated that the amount of water furnished by a driven well depends on the fineness of the material in the various strata from which the water is obtained, the thickness of the water-bearing stratum, the diameter of the well, and the distance the surface of the water is lowered by pumping. The influence of the fineness of the water-bearing material has been studied by Prof. Slichter and others and tables have been prepared by which its effect can be readily estimated. The other factors have been more generally understood, but their relations with each other and with the transmission constant of the material have not been experimentally investigated to any extent prior to the work done by the Geological Survey. It is unnecessary to explain in detail here the methods that have been developed by the engineers of the Survey, for a full account of them will be found in Prof. Slichter's "Field Measurements of the Rate of Movement of Underground Waters," published as one of the water supply and irrigation papers of the Survey. By their use the older method of indiscriminate pumping, hardly more useful than the divining rod of witch hazel, is relegated to the list of crude approximations, good enough for many purposes, but not satisfactory for careful investigations.

Ventilating the New York Subway.

Three weeks ago attention was called in this journal to a valuable report concerning the sanitary conditions in the New York subway by Dr. George A. Soper, whose investigations showed that the air was of entirely satisfactory character during the six months his examinations were conducted. This week Mr. George S. Rice, chief engineer of the Rapid Transit Railroad Commission, made public a report equally important, based on investigations of the ventilation problem which were begun a year ago. When the plans for the subway were prepared it was assumed that the movement of the trains would cause sufficient circulation of the air to keep it of satisfactory quality, but it could not be determined at that time what should be done to remove the heat due to the electrical operation of the trains. The importance of the subject was recognized from the beginning, but until measurements showed how much of the heat would be dispersed through the floor, walls and roof it was impracticable to plan means for cooling the subway. The problem was not one of ventilation, in the ordinary sense, but of removing heated air. The measurements made last summer have furnished the data required to solve the problem partly, and Mr. Rice estimates that an expenditure of $275,000 will make the condition of the subway during the next summer far more comfortable than it was last season.

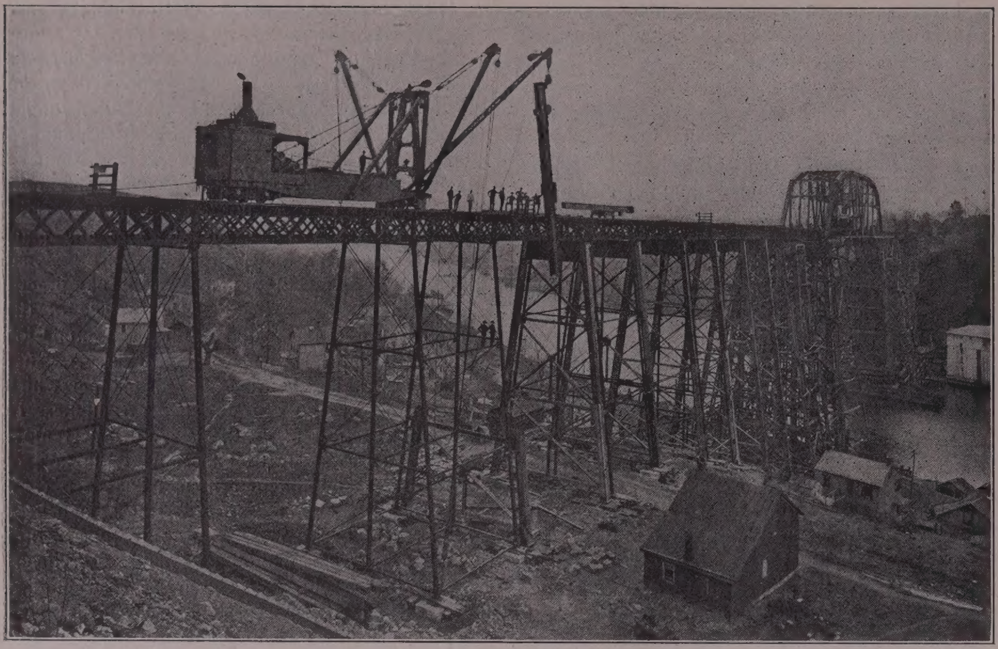
About 83 per cent. of the energy furnished from the power station is stated by Mr. Rice to appear as heat in the subway, and when the ultimate train schedule is in use the amount of heat set free will be about twice that which was given off last year. A little of it escapes through the passages connecting the stations and the streets, but the greater part is dissipated through the floor, walls and roof into the adjoining ground. The effect of the remainder is to increase the temperature in the subway from 12 to 20 deg., according to the season of the year. The ventilation must be designed so as to renew the air more frequently than now happens and also often enough to carry away the fine particles of iron dust due to the wear of the cars and rails.

Most engineers will probably approve Mr. Rice's decision to exhaust the air at points midway between the stations. This not only maintains the freshest air at the stations, where it is most needed, but also takes out the iron dust, which has more or less serious effect on the lungs, in the least objectionable manner. It also prevents the escape of smoke through the station exits in case of fire, which is highly desirable, as the platforms and passageways to the streets are then likely to be crowded with people whom a blinding cloud of smoke would convert into an uncontrollable mob.

Two methods of removing the air have been found to be practicable by the experiments made during the past year. The first of these is by means of louvres, so constructed that they will open outward only, and so balanced that they remain closed except when the interior air pressure is greater than that outside. When a train approaches an opening provided with such apparatus, the air pressure forces the louvres open and an outflow of air occurs until the train passes, when they at once close. The air necessary to replace that forced out can only enter through the station openings, and in this way an intermittent circulation is set up. The apparatus now in use has shown that about 20,000 cu. ft. per minute were discharged through 100 sq. ft. of louvres during the hours of maximum train movement, and only 5,000 cu. ft. during the hours of least train movement. This movement is not enough to take out the heated air during the summer, and it is accordingly proposed to combine fan chambers with the louvre chambers along subway sections where the temperatures are highest. The train movements will be relied upon to keep up a circulation of the air during the day time. The circulation of the air through the louvres will be permitted at all times, while during the summer nights the fans will also be run, as well as at such other times as seem necessary. It is also proposed to make these chambers somewhat larger than requisite for ventilation alone, so that in case of accident they may serve as exits to the streets.

In addition to these improvements some means of cooling the air will have to be provided. At the present time it is impossible to determine what method will serve best, whether the evaporation of water, refriegration, or the absorption of the heat by disposing water through the subway in some manner. The problem is so unusual and of such magnitude that the Commission's chief engineer has very wisely decided to go slowly and make experiments in the subway under actual summer conditions before attempting to reach a solution of it. It is very easy to make suggestions and to work up a considerable reliance in their efficacy, but it is a more serious matter for the Commission to adopt any plan. In the one case only individual professional judgment is affected by an unfavorable practical result; in the other case the people of the city will lose some confidence in a Commission which they have learned to regard as very sure of success, even if it proceeds in a manner which seems slow at times to the general public. In this whole matter of ventilation and heat removal, the course of the Commission in the face of more or less intelligent criticism has been commendable. Although it may at times have been disgusted to observe assertions directly contrary to fact in journals claiming to make some investigation of a subject before passing an opinion on it, it has never stooped to newspaper controversy. Rome was not built in a day, and this important problem of cooling the subway cannot be solved by guess-work and an engineer's pocket-book. It has been fully appreciated by the Commission's engineers from the outset, and the only reason that it has not been solved before was because the data for the solution had to be ascertained by experiment in the subway itself under operating conditions. The engineers of the Commission are men of high standing and ripe experience, and they are as well acquainted with the laws of nature and their direction to useful purposes as some of the anonymous critics who endeavored to stir up the public last summer by criticisms that were both unwarranted and ignorant. There was no question about the heat in the subway or that its diminution was highly desirable, but the assertion that this heat was unexpected and its cause not foreseen was unjust to the engineers who had been studying the problem for a long time.

THE ALABAMA STEEL INDUSTRY is to be materially expanded, if half the statements attributed by the papers this week to Mr. John W. Gates come true. The natural resources of the region are so great that unquestionably its output of steel would have been far greater to-day but for the vigorous action of Northern competitors in retarding the investment of capital there, the scarcity of reliable labor and high freight rates. A great deal has been published concerning the poor quality of the Southern raw materials, yet the great German steel industry has developed from far poorer materials. Alabama has been waiting for some iron master with the business ability to overcome the artificial restraints that have hindered the working of the collieries, mines and steel plants of the State as they naturally should be. Whether the union of the Tennessee Coal, Iron & Railroad Co. with the Republic Iron & Steel Co. will result in the great development of the steel business of the Birmingham district remains to be proved. There have been too many emphatic detailed statements on the subject in newspapers that sell their reading columns to masters of high finance for the engineer to be without some suspicion that rumor has been magnifying the real intentions of the Gates-Schley-Hanna interests. On the other hand, the possibilities of Alabama as a steel center are very great and Mr. Gates has a higher reputation as a director of steel industries than that acquired in some other ventures with which his name has been connected. If he develops the Southern business as reported he will deserve much praise.



Erection of New Tower Columns in Temporary Position.

REBUILDING THE RONDOUT VIADUCT.

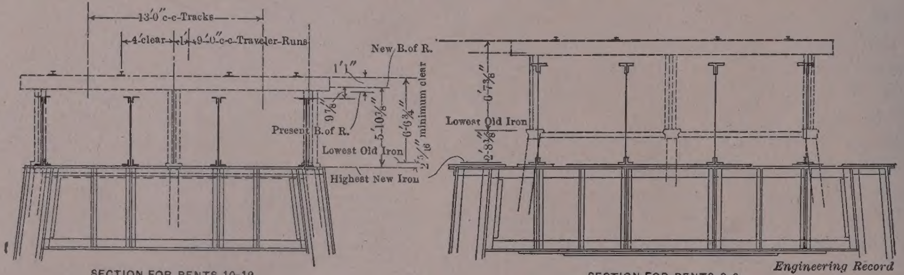
The West Shore R. R., now a portion of the New York Central & Hudson R. R. system, was built in 1880-1883 and crosses the Rondout creek about one mile from Kingston, N. Y., on Bridge No. 141, which is the longest structure on the line, being 1,228 ft. between abutments and having a height of 154½ ft. from high water to base of rail. The original structure consisted of nine towers, made with Phœnix columns and pin connected diagonals carrying three iron through Whipple truss spans of about 163 ft., 241 ft. and 264 ft., and seven viaduct spans of 50½ ft. to 60 ft. The through spans were each made with two trusses 29 ft. apart on centers and the deck spans were made with three lines of lattice girders about 10 ft. apart. The substructure consisted of three masonry piers 15 ft. wide, with pile foundations for the main span towers and of six separate masonry pedestals rising just above the surface of the ground for each of the five viaduct towers 29½ ft. long and for the single viaduct tower 20 ft. long. The bridge was designed for 82-ton locomotives and 30-ton cars operated at comparatively low speeds.

The recent improvements intended to make this road take the fast and heavy freight and traffic called for a heavier structure which has just been built to replace the old one and which was designed for a live load of two Cooper's E40 locomotives followed by a train load of 4,500 lb. per lin. ft., running at high speed, the structure being proportioned for such low unit stresses that it will safely permit the use of locomotives 20 per cent. heavier than those above specified. The new bridge is on the same center line and has the same general dimensions as the old one but differs from it in the character and arrangement of the spans. The channel span is increased to 270 ft., giving it bearings over the centers of the original piers instead of near their river edges as formerly. The 163-ft. and 241-ft. through spans have been replaced by one 143-ft. deck span and four plate girder spans of 29½ ft. to 77½ ft., supported on two towers and one rocker bent on the north side of the creek, where the lengths and positions of the spans are unchanged except that the span nearest the channel is 67½ ft. instead of 60 ft., corresponding with the change of the tower.

All of the short spans are made with four lines of plate girders and the towers are made with heavy rectangular columns like ordinary top chord sections, which except in the rocker bent and under the channel span form transverse bents braced together longitudinally in pairs. Both transverse and longitudinal bracing is made with stiff members and riveted connections and the columns are field spliced in two or three sections, acording to height. At the top of each intermediate bent the battered columns are connected by a deep transverse plate girder carrying on its top flange the longitudinal girders which meet on the center line. At the end of the 270-ft. channel span the trusses are supported on a special box girder. All of the regular towers are 29½ ft. long. Those for the channel span are special and are tapered both longitudinally and transversely so as to have narrow tops and wider bases occupying the original foundation piers. The whole substructure remains unchanged except in some cases where it was necessary to rebuild some of the pedestals for the viaduct towers or to renew the upper courses of the pier. Additional piers and pedestals were built for the towers on the south side of the river where the through spans were replaced by shorter deck spans.

It was required to replace the old structure by the new without interrupting the train service. This requirement together with the height of the track above water level, the poor quality of the bottom, the depth of the water, and the necessity of preserving a wide opening for navigation, made the erection of the bridge exceptionally difficult and expensive. It was commenced by the replacement of the channel span as illustrated in The Engineering Record of July 16, and December 24, 1904. Afterwards the other through spans and the old approach girders and towers were successively replaced by the new ones and the work has been safely completed and the new structure in service for several months.

The replacing of steel or iron viaduct towers and spans with new ones on the same substructure without interrupting traffic has always been considered one of the most difficult of the problems developed by the wholesale renewal of railroad structures which has been in progress throughout this country since the original iron bridges commenced to be replaced by steel. The fact that the new structure generally occupies almost or quite exactly the center lines of the old one and has nearly the same dimensions throughout, generally makes it impossible to build it to clear the old structure either inside or outside, even if the footings would not occupy the same positions on the old masonry. It appears almost impossible to remove the old towers so as to set the new ones in their place without destroying the whole structure and stopping the traffic unless the track is carried by independent falsework. In a case where the elevation is great above the ground or water level the construction of falsework becomes very expensive. In this bridge a novel and ingenious method was adopted which called for considerable skill and courage and by its successful accomplishment reflected much credit on the contractor and the engineers responsible for it. The north approach viaduct was jacked up 13 in. and the bases of the tower columns were supported on horizontal rails carrying them on temporary supports clear of the masonry while the latter was repaired and new coping was set. After the erection of the channel span and its supporting pyramidal steel towers, pile and trestle falsework was built under the two adjacent through spans supporting them and the tracks independently and the former were taken down in the usual manner with an ordinary gantry traveler which also erected the new deck spans and towers, while the traffic was carried on the falsework. The transverse bents of the new viaduct towers on the opposite side of the creek were then erected without falsework by a traveler, running on the old structure, which consisted of a special platform car rigged with three derrick booms as shown in the accompanying illustration. It lowered the different members and sustained them until assembled together in complete bents seated on solid temporary footings as close as possible to the faces of the old towers. The new tower bents were temporarily secured by horizontal longitudinal struts bolted to them and across the faces of the old towers.

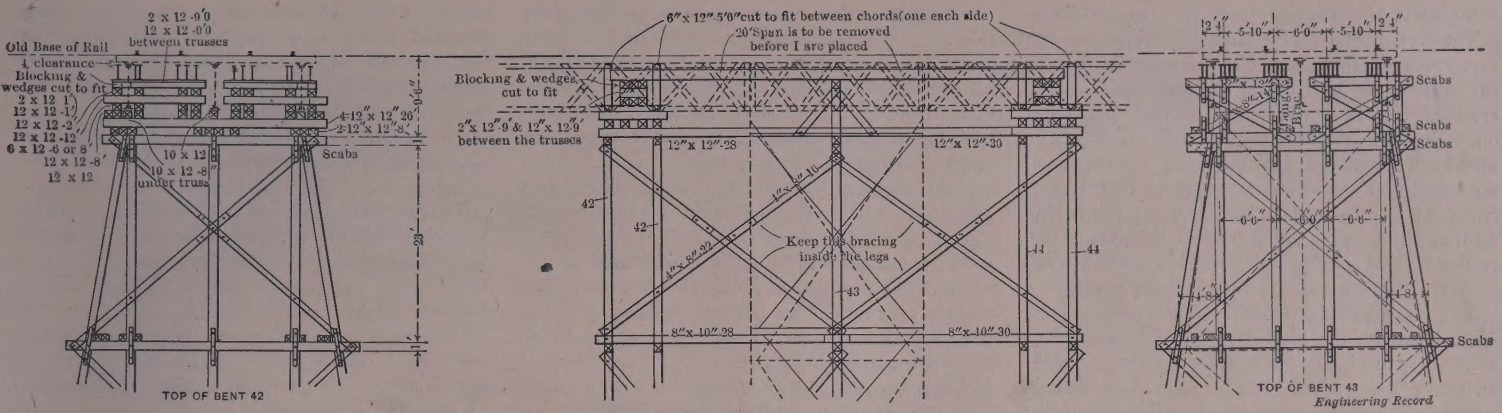


SECTION FOR BENTS 10-19

SECTION FOR BENTS 8-9

Sketches Showing Methods of Erection.

After all the bents were erected the derrick car, commencing at the north end of the bridge, moved backwards to the south end on the east track, which had been given up for erection service, traffic being concentrated on the west track where it was completely uninterrupted. The first three spans of old lattice girders under the east track were removed and in their place the new plate girder spans for the west track were assembled and riveted up complete. During an interval between trains the west track was blocked up free of the old girders and they were transversely slid out of position while the new girders

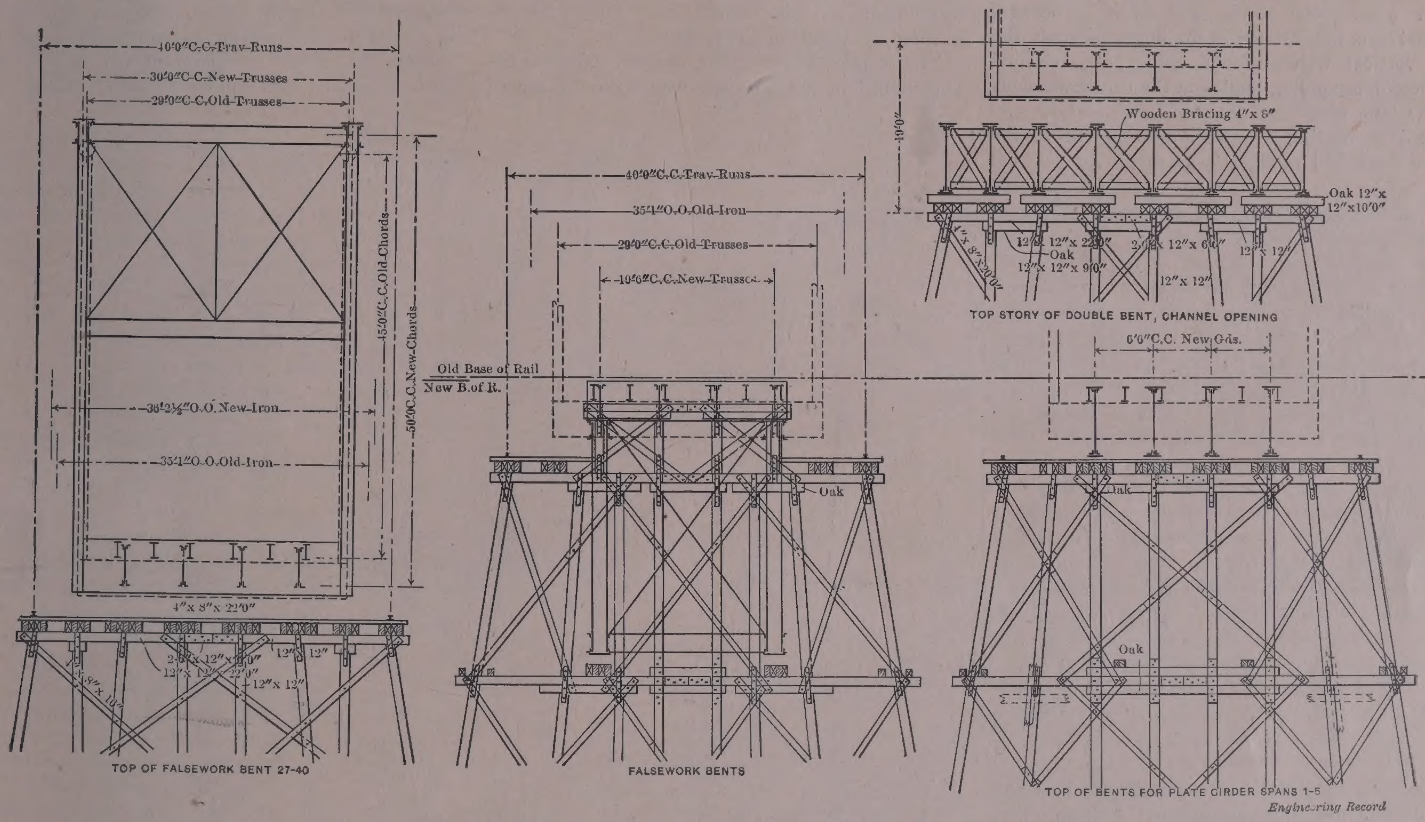


TOP OF BENT 42

TOP OF BENT 43

Engineering Record

Falsework Tower for Erection of Plate Girders at North End of Channel Span.



TOP OF FALSEWORK BENT 27-40

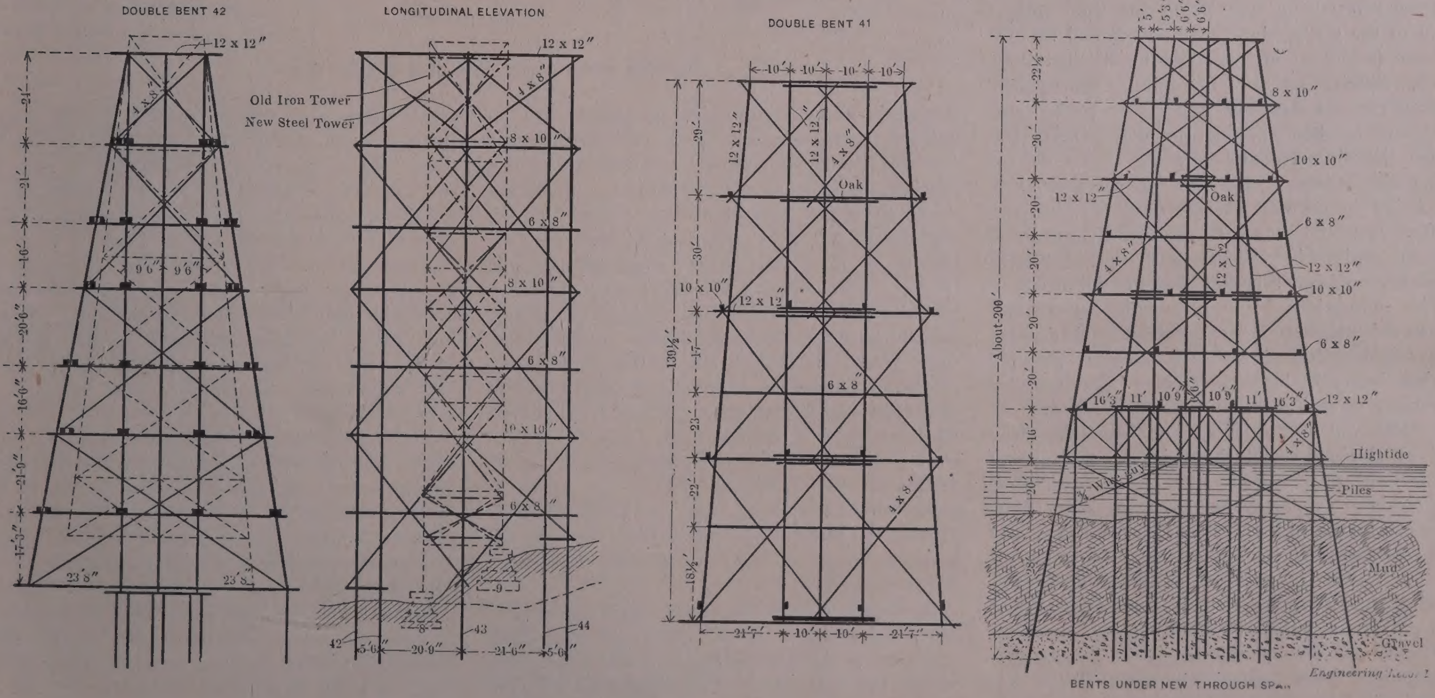
FALSEWORK BENTS

TOP STORY OF DOUBLE BENT, CHANNEL OPENING

TOP OF BENTS FOR PLATE GIRDER SPANS 1-5

Engineering Record

Tops of Bents used in Erection of the Rondout Bridge.



BENTS UNDER NEW THROUGH SPAN

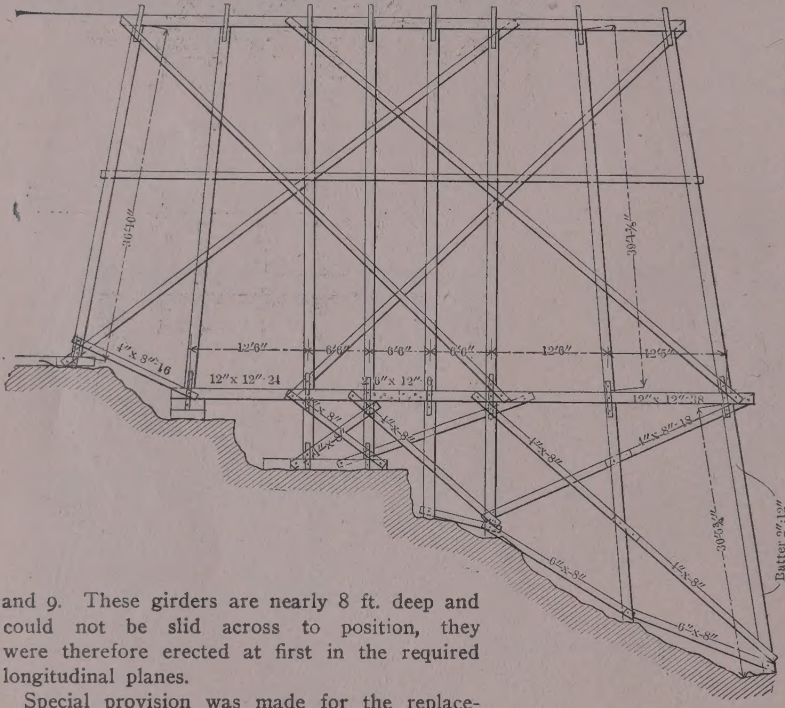
Engineering Record

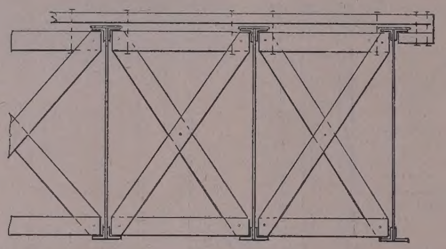
Diagram of Trestle Bents used in Erecting the Rondout Viaduct.

were slid beneath the track to replace them.

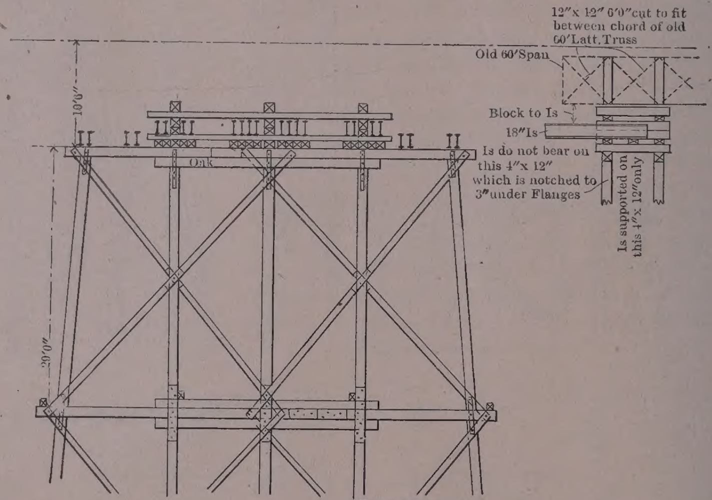
The new girders were then assembled for the east track on these three spans and the derrick car started southwards again, repeating the operations for the other spans of the approaches on both sides of the river until all of the plate girders were placed approximately in their final positions, and traffic was admitted to both tracks. Switches were placed at both ends of the bridge so that either track could be cut out quickly and traffic carried on the other. This plan worked well and prevented any interruption to traffic.

The plate girders connecting the towers varied from about 50 to about 77½ ft. in length. The regular spans being 50½ ft. connected by 29½-ft. tower spans. The 50½-ft. connecting girders were first seated across the top flanges of the new transverse tower girders, overhanging them 3 or 4 ft. The tower girders were brought in and secured by 18 ⅞-in. bolts through the end vertical web stiffener angles at each end to the corresponding angles in the cantilever ends of the long girders, thus forming temporary suspended connecting spans. An exception to the above described methods was made for spans 8 and 9. These girders are nearly 8 ft. deep and could not be slid across to position, they were therefore erected at first in the required longitudinal planes.





METHOD OF FASTENING SASH TO BRACE FRAMES


12"x 12" 6'0" cut to fit between chord of old 60' Latt. Truss
Old 60' Span
Block to Is
18" Is
Is do not bear on this 4"x 12" which is notched to 3" under Flanges
Is supported on this 4"x 12" only
10'6"
Oak
29'0"

Engineering Record

Blocking under South End of Old 60-ft. Span

Special provision was made for the replacement of the girders by a method adapted for use in case it had proved possible to obstruct both tracks simultaneously. The plan contemplated cutting the old ties near the center girder and removing it, then erecting the new girders between the old ones and carrying the traffic on either old or new girders. All of the new girders being in position at once and carrying the traffic. It would thus have been possible to leave the old girders in position until the old towers were removed but this plan was not followed.

The connections between the old towers and the new bents were removed and the old towers successively taken down as rapidly as possible during intervals between trains. The traveler advanced to the shore end of the first span at the north end of the bridge and lifted the river end of this span and the adjacent end of the connecting 30-ft. tower span which had previously been supported by the tower bent. Simultaneously the old tower was disconnected and removed and then, hydraulic jacks being set horizontally against the feet of the new columns, and tackles attached to their tops, they were pushed and pulled from their temporary to their permanent positions without the use of the derrick car. Connections were immediately re-established between this bent and the longitudinal struts and the traveler moved forward to a position over the bent and lifted the connected ends of the long and short girders over the second tower bent and swung the released bent to its permanent position as already described. The connections with the longitudinal struts were temporarily re-established and the permanent longitudinal bracing between the tower bents was assembled and connected, thus completing the tower.

This method involved the longitudinal movement of all the girders about two in. from their temporary to their permanent positions because it had been necessary to seat them originally so as to clear the old iron work. This method of erection proved much cheaper and more rapid than the construction of complete falsework for so high a viaduct, one tower and the adjacent span being erected complete in a single day by a force of about about 50 men.

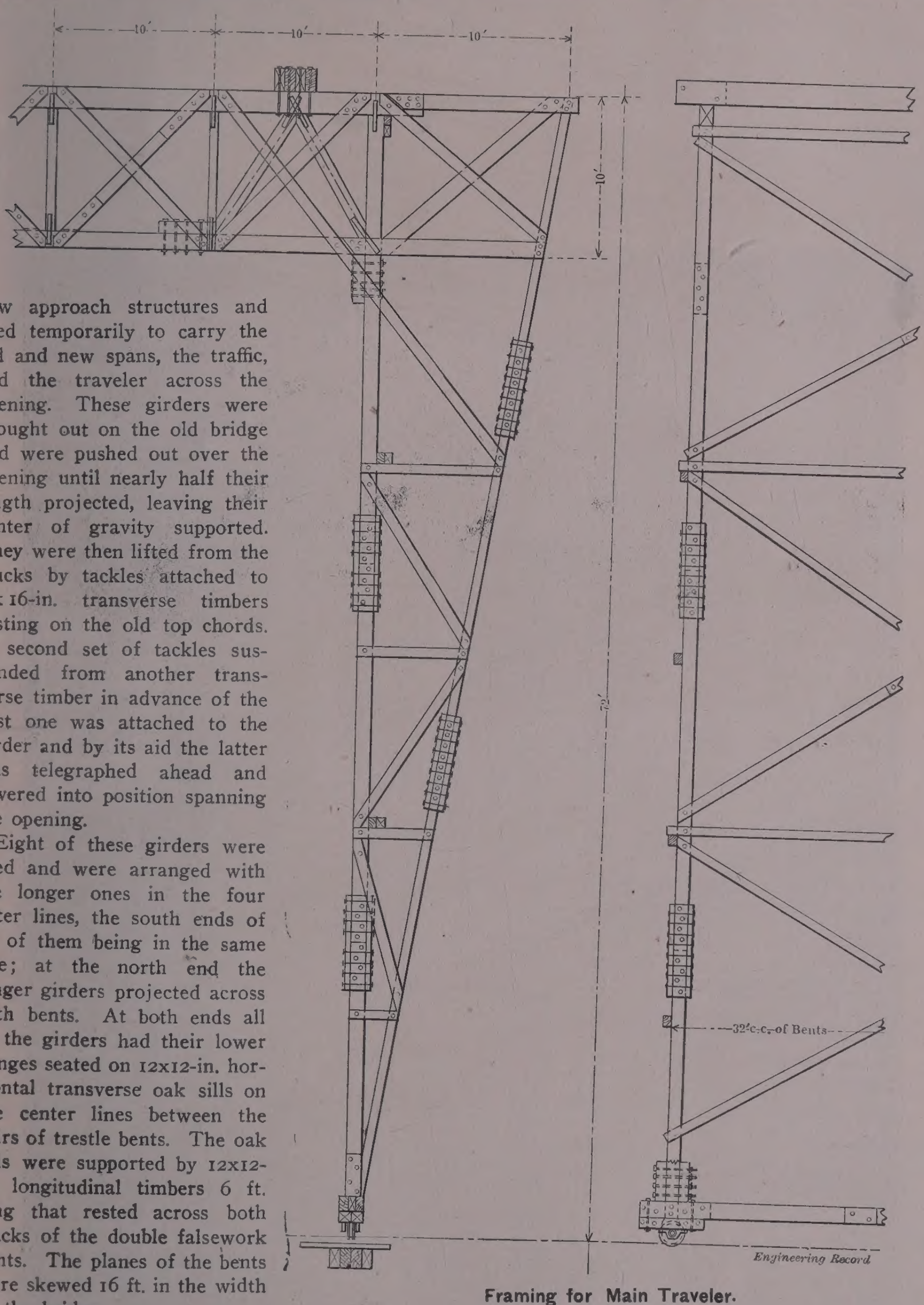
The erection of the 270-ft. channel span was accomplished in the ordinary way with the use of falsework exceptionally high, provided with an opening 63 ft. wide and 138 ft. high in the clear over the channel to allow for navigation, which consisted principally of schooners and barges towed by tugs. This span was erected and its predecessor was taken down on a falsework consisting of 16 framed bents supported on pile trestles. The adjacent old 241-ft. span was supported during its removal on 15 bents of similar falsework and 11 bents of shorter framed falsework seated on ground sills without piles were erected on the steep bank above water level to carry the old 163-ft. span during its removal. This falsework also sufficed to carry the tracks and to support during erection the new 143-ft. deck truss span and the plate girder approach spans, the latter being thus rendered independent of the method of displacement with the old structure which was used at the opposite or north end of the bridge.

Under the channel span the regular falsework bents were spaced 15 ft. apart and were built as shown in the general diagram and detail view of the upper portion. The framed bents were made in four stories and all of them were duplicates. Each had four vertical posts and four battered posts all of 12x12-in. pine timber put together with steel scabs across the 12x12-in. sills and caps at every story. The latter were made with two pieces each, spliced on the vertical center line of the bent with a pair of 6x12-in. yellow pine scabs bolted to opposite vertical faces of the timber.

The vertical posts in nearly all cases were provided with top and bottom bearings on 12x12-in. oak timbers seated on the upper and lower faces of the intermediate trestle caps and secured between pairs of 6x12-in timber scabs 6 ft. long connecting the vertical posts across the sills and replacing at these points the steel scabs which, as above stated, were generally used. The inclined posts were battered 1:6.

Each story was X-braced as indicated in the diagram with single 4x8-in. pieces in lengths of 14 to 22 ft. lap spliced at joints with 4x8-in. wooden fish plates on their vertical sides. The lower stories were intermediately braced by single horizontal 6x8-in. timbers bolted across them. Longitudinally the bents were braced by four lines of horizontal struts bolted to each of the caps and intermediate struts as indicated in the general diagram, making in all about 20 lines of struts exclusive of the 20 lines of 8x16-in. stringers 32 ft. long which were arranged in groups of six under each track, two under each truss and two under each traveler rail. Where the towers interfered with the regular spacing of the bents the latter were placed farther apart and 18-in. steel I-beams were used in place of wooden stringers.

Each framed bent of the channel span was supported on fourteen vertical and two battered piles about 80 ft. long driven through 20 to 25 ft. of water and 28 ft. of soft mud by an ordinary 2,600-lb. hammer mounted on a 20x60-ft. scow. The piles were arranged in pairs under each of the trestle posts and were braced by a 6x8-in. horizontal strut at high water level. The panels between this strut and the 12x12-in. cap were X-braced by single 4x8-in. timbers inclined at an angle of about 45 degrees. Between high water line and the top of the mud the piles were braced with two panels of ¾-in. wire rope diagonals looped around the piles and secured to them at the lower end before the former were driven. The falsework bents were assembled on the pile caps and hoisted into position, a story at a time, by tackles suspended from the old spans.



Framing for Main Traveler.

On each side of the opening for navigation two regular bents of falsework were set as close together as possible to carry the extra load due to the 77½-ft. and the 69-ft. plate girders which were borrowed from spans one and four of the new approach structures and used temporarily to carry the old and new spans, the traffic, and the traveler across the opening. These girders were brought out on the old bridge and were pushed out over the opening until nearly half their length projected, leaving their center of gravity supported. They were then lifted from the trucks by tackles attached to 8 x 16-in. transverse timbers resting on the old top chords. A second set of tackles suspended from another transverse timber in advance of the first one was attached to the girder and by its aid the latter was telegraphed ahead and lowered into position spanning the opening.

Eight of these girders were used and were arranged with the longer ones in the four outer lines, the south ends of all of them being in the same line; at the north end the longer girders projected across both bents. At both ends all of the girders had their lower flanges seated on 12x12-in. horizontal transverse oak sills on the center lines between the pairs of trestle bents. The oak sills were supported by 12x12-in. longitudinal timbers 6 ft. long that rested across both tracks of the double falsework bents. The planes of the bents were skewed 16 ft. in the width of the bridge

The falsework bents were X-braced together longitudinally in most panels by diagonals intersecting intermediate bents in the center so as to maintain an inclination of about 45 degrees. Opposite one of the old piers and one of the new piers and in four intermediate panels of the river falsework the longitudinal diagonals were omitted as was also the case in every third panel of the shore falsework, thus converting the falsework into twelve towers separated by single panels without longitudinal bracing, but which were crossed by the horizontal timbers. Nearly all of the stringers on top of the falsework consisted, as already noted, of 8x16-in. timbers in double panel lengths, but in six panels of the 241-ft. span the twelve center lines of stringers were composed of the iron stringers from the old span, and in the adjacent pier span 18-in. I-beams were used instead of timber and were supported 10 ft. below the top of the falsework by the regular falsework bents on each side of the pier, 30 ft. apart and carried four pony bents on which the 8x16-in.stringers were laid.

The eight plate girders spanning the channel opening were securely braced together by a set of vertical wooden cross frames at each end and by three intermediate sets. Each set was composed as indicated in the partial sketch, of 4x8-in. horizontal and diagonal timbers fitted to the flange angles. In the planes of these braces single 4x8-in. horizontal struts were run across the top flanges of the girders and secured to them by bolts and outside bearing pieces as indicated in the detail. Two of the intermediate lines of bracing had similar horizontal struts secured to the lower flanges of the girders. The span was also X-braced by two sets of 4x8-in. diagonals bolted to the top flanges of the girders, each of them reaching from the center to the end of the span.

The falsework for the new deck truss span differed from that for the new through span chiefly in the upper stories where pony bents about 8 ft. high were set between the caps to support the shallow stringers of the old floor. These bents had double caps 24 in. deep made with two courses of 12x12-in. timbers supported by four vertical posts thoroughly secured with steel scabs at the upper and lower ends. The top chords of the new trusses just cleared the lower sides of the caps and were supported from the main caps by blocking about 4 ft. high.

The shore falsework under the old spans was substantially like that for the new deck span except in the upper story which supported the old floorbeams and the new plate girders without the interposition of pony bents. The main caps carried twenty lines of 12x16-in. stringers in groups of two and three on the centers of the posts as indicated in the detail elevation. The 4x8-in. ties for the traveler track are each made with two 22-ft. lengths abutting on the center line of the bridge. They are spaced about 24 in. apart on centers and on them the old structure was blocked up during its removal.

The falsework bent on the shore side of the pier at the north end of the channel span was at first designed to be made double with each part as indicated in the diagram; eventually this design was modified by making the legs each with two 12x12-in. timbers in the same transverse plane instead of with one as shown, and by lowering the top cap. The traffic tracks and traveler tracks were respectively carried over by sixteen and by four lines of 18-in. I-beams, twenty in all, arranged as indicated by the detail elevation, where, however, there appear to be 24 lines. This is due to the fact that no distinction is made between the I-beams shown in cross section and some other I-beams which should be represented in end elevation but are drawn with the others so as to show their arrangement in pairs, where the ends of adjacent spans overlap on the same support.

It was not practicable to erect the plate girder spans adjacent to the north end of the channel span in the same manner that the rest of the spans on this side of the river were handled. Therefore the old tower 8-9 was removed and the new tower was built on the same substructure by means of a special falsework tower made as indicated by the elevation diagrams with one center bent and two double side bents. The transverse members of the center bents were threaded through both old and new towers and were arranged to clear their members. The longitudinal bracing in the upper story was arranged inside the steel and iron tower members. All other members of the falsework were located outside of the steel work.

The longitudinal stringers across the caps of the bents received special blocking built up in sets over the double bents so as to support the ends of the 12 lines of 18-in. 55-lb. I-beams 28 ft. long, which overlap each other and are supported at the center of the tower by a pony bent on the double cap of the center falsework bent. These carried the tracks while the old spans and towers were removed and the new tower was built. The new plate girders not being erected in this case until after the new tower had been built inside the falsework tower in the space already vacated by the old structure.

After the completion of the falsework tower the first operation was the removal of one of the old 20-ft. tower trusses which enabled six lines of I-beams to be put in place and a track laid on them to carry the traffic which was then diverted from the other track and the latter, together with the two remaining tower trusses, were removed, thus freeing the old tower; the lower caps of the double outside bents of the falsework tower meanwhile supporting the temporary cantilever ends of the old lattice girders in the adjacent spans, thus making it possible to proceed with the replacement of the tower.

Nearly all of the falsework was seated on the caps of pile trestle bents, but bents 3 to 11 inclusive were located on shore and the lower ends of the vertical and inclined posts were set directly on the leveled surface of the rock. The heights of the seats were varied greatly so that all of the lower stories of the bents were irregular. One of the most irregular was bent nine and the elevation of it illustrates the general method of bracing the feet of the posts and of connecting their caps to the bottoms of the framed bents, thus practically forming sills for the latter. This bent differs from the others in that on the high side the end of the cap is seated directly on blocking instead of on a short post and that some of the posts are seated on transverse sill pieces instead of resting directly on the rock. This modification was used because in the absence of rock a greater bearing was required.

The horizontal longitudinal struts securing the posts of the incompleted new towers to the old towers were made with a 20x24-in. rectangular cross section composed of four 3x3x⅜-in. angles, one at each corner, with their flanges turned inwards and connected by tie plates and lattice bars on all four sides. The intermediate tie plates were arranged at the points where the struts intersected the old and new tower members and were pierced in each of these places with holes for four 2-in. horizontal bolts connecting them to the towers. At these points the horizontal tie plates were stiffened by short transverse angles with their ends bearing against the inner flanges of the main angles so as to form separators receiving the reactions from the connection bolts. The complete struts were each about 92 ft. long and were made in three nearly equal pieces. The bolted joint at the center of the strut was made with slotted holes allowing for a slight longitudinal adjustment, the other field joints were made with bolts through round holes and did not allow for adjustment.

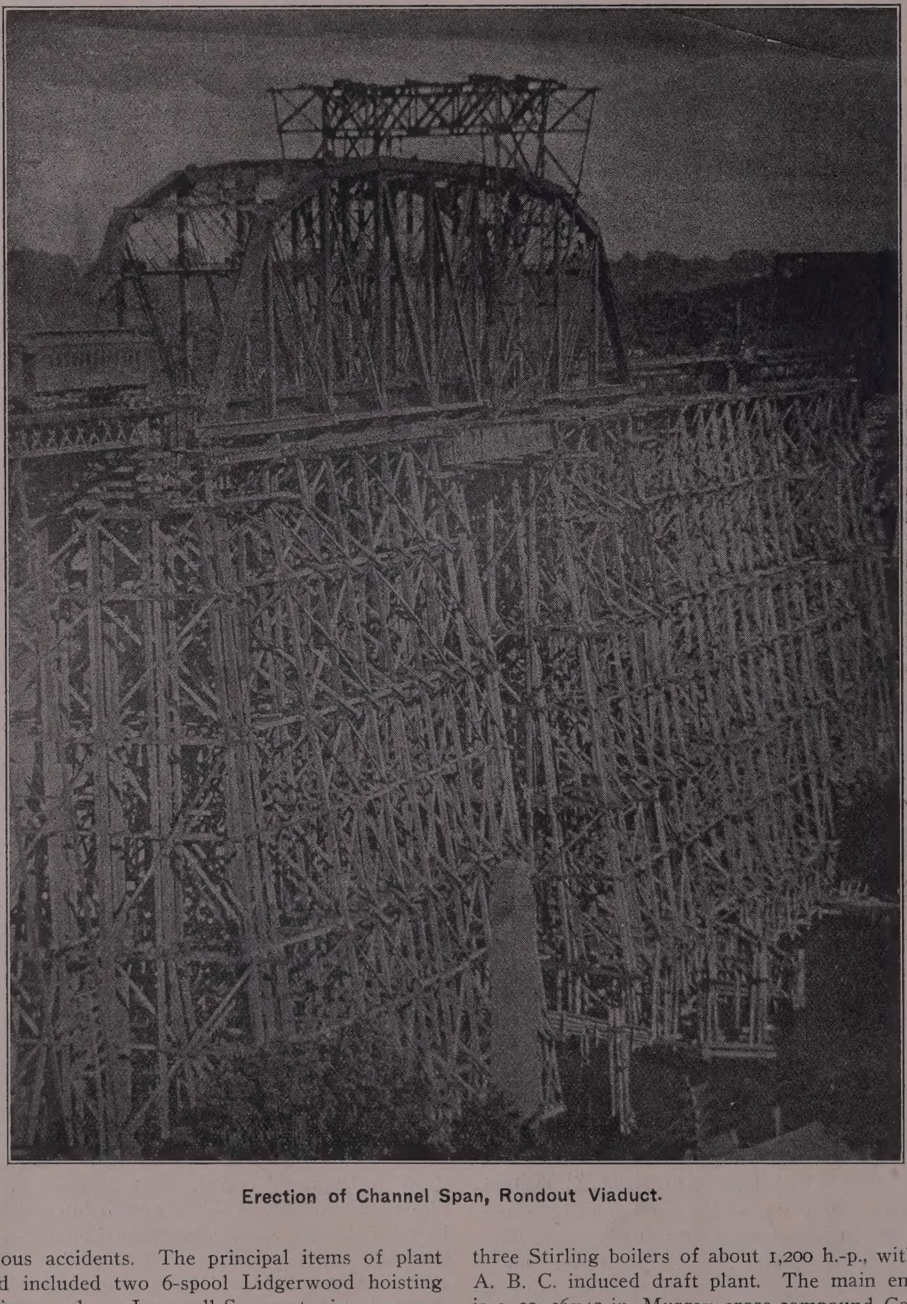
The steel for the superstructure was delivered by cars to a storage yard on top of the bank about 500 ft. south of the bridge. It was unloaded by two standard American Bridge Co. steel derricks with 40-ft. masts and 65-ft. booms, and was classified and stored in piles until delivered for erection on small cars pushed by hand to the bridge site. The old spans were removed by the use of an ordinary wooden gantry tower traveler having horizontal and vertical clearances of 37½ ft. and 62 ft. respectively. It was made with two transverse bents 34 ft. apart and was mounted on four double flange wheels running on a track of 40-ft. gauge. Each bent was 40 ft. wide on centers at the bottom and 64 ft. wide on top and had two 10x10-in. vertical posts and two 6x10-in. inclined posts, all of them made with three pieces each and spliced with four wooden fish plates at each joint.

The vertical and inclined posts on each side of the bent were braced together in the usual way by zigzag 4x8-in. timbers. The tops of the posts were connected by a Howe truss with a 10x16-in. cap piece or top chord and a 10x12-in. piece for the bottom chord. Both pieces terminated at the vertical posts and were extended to the inclined posts by pairs of 4x12-in. pieces 12 or 14 ft. long spliced to their ends. The vertical posts of the truss were made with single 6x10-in. pieces and the inclined posts were made with pairs of 4x8-in. pieces bolted across the outer faces of the chord timbers. The top chords of the two trusses supported two lines of jigger beams each made with a pair of 8x16-in. stringers. Each jigger beam was 15 ft. from the center line of the traveler and was supported in the middle of the panel, the top chord at this point being reinforced by a special pair of 10x10-in. inclined posts reaching to the adjacent bottom chord panels.

The traveler was built throughout of southern yellow pine, merchantable inspection Savannah rules and contained 20,000 ft. B. M. of timber and had an estimated weight of 90,000 lb. It was proportioned for maximum live loads of 15 tons for column sections, 34 tons for transverse girders, 20 tons for longitudinal girders, and 15 tons for chord sections. The heaviest reaction at one corner of the traveler, exclusive of the dead weight of the traveler, was assumed to be 35,000 lb. when handling the girders and 28,000 lb. when handling the trusses.

The floor system for the channel span was first assembled, after which the trusses were erected and the pins were driven from the outsides of the trusses with a 400-lb. battering ram, made from a section of steel rail. Field rivets were driven by pneumatic hammers and were bucked up by hand. The superstructure weighed about 3,000 tons and was erected by an average force of 50 men in about six months. It is notable that notwithstanding the great height of the structure and the difficult character of operations the work was completed without any fatalities or serious accidents. The principal items of plant used included two 6-spool Lidgerwood hoisting engines and an Ingersoll-Sergeant air compressor with a capacity for eight hammers, besides the other plant already mentioned. The hoisting engines were stationarily located on platforms projected from one side of the falsework and moved from place to place as the work progressed.

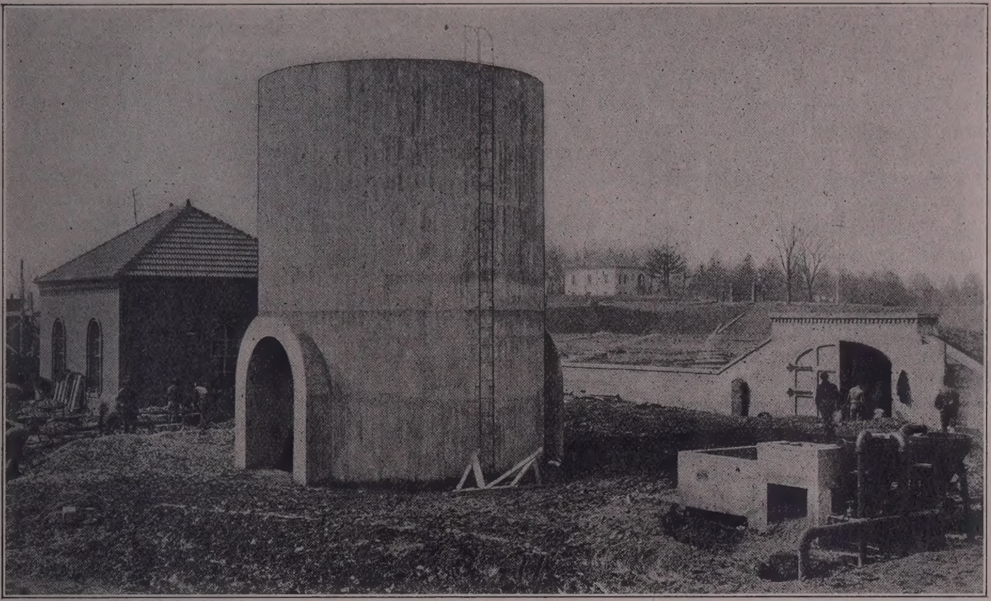
The design and erection of the bridge were directed by the Engineering Department of the New York Central and Hudson River R. R. Mr. W. J. Wilgus, vice-president, Mr. Olaf Hoff, engineer of structures, and Mr. A. W. Carpenter, engineer of bridges. The 270-ft. span weighed 798 tons and excepting the eyebars, which were made at Athens, was built at Edge Moor. The whole of the superstructure was built at the Edge Moor, Athens, and Pencoyd plants of the American Bridge Co., of New Jersey. Mr. Paul L. Wolfel, chief engineer. The bridge was erected by the American Bridge Co., of New York. Mr. S. P. Mitchell, chief engineer, and Mr. H. F. Lofland, manager of the eastern division.



Erection of Channel Span, Rondout Viaduct.

Electric Power in a Saw Mill.

Electric power is used to a considerable extent in the large saw mill of the Katahdin Pulp & Paper Co., of Lincoln, Me. The power station has three Stirling boilers of about 1,200 h.-p., with an A. B. C. induced draft plant. The main engine is a 20x36x42-in. Murray cross-compound Corliss engine with a Dodge rope drive to the main shaft furnishing power to the saw mill proper. To this is connected a 250-kw., three-phase, 60-cycle, 600-volt generator, which furnishes power to five induction motors of 75 to 200 h.-p. each, driving mainly the planing mill and the machines for preparing chips for the sulphite process from the spruce waste. The generator and motors were furnished by the Geenral Electric Co.



Bin for Storing Washed Sand.

The Washington Water Filtration Plant.

By E. D. Hardy, M. Am. Soc. C. E., Superintendent.

On Aug. 18, 1905, the first filtered water for Washington, D. C., was turned into the filtered water reservoir. This water was mixed with the unfiltered water from the Washington City reservoir, and supplied to the consumers. The next filter was put into operation four days later, and the others followed in order one after another, with intervals of about two days, until, on Oct. 5, the raw water was shut off, and none has been let into the mains since. (For descriptions of plant, see Eng. Record of March 14, 1903, April 16, June 25 and Nov. 5, 1904.)

During the first two months after the filters were started, the turbidity of the raw water was low and that of the filtered water practically zero. In December, however, there was a decided increase in the turbidity of the raw water at Great Falls, the Potomac River water being 1,500 on one day, as measured by the U. S. Geological Survey standard, and the general average to Jan. 5, 1906 was high. Although a good deal of this mud was deposited in the three sedimentation reservoirs, enough was left to overtax the filters, so that the effluent water was cloudy, and continued so during January. In February and March the applied water was less turbid on an average and consequently the filtered water has been quite satisfactory, although it is not a brilliant water.

The Potomac water contains a turbidity-producing material of such a character that it is a difficult water to treat, at times of high turbidity, without a coagulant. Like other southern rivers, the suspended matter consists of clay, and the particles remaining after a short period of sedimentation are very finely divided. For this reason the coagulant has been advocated for such periods of time as are found to be necessary to prepare it for satisfactory clarification by slow sand filtration. It seems probable that such treatment will only be necessary for about forty days of each year, and that a rather high rate of filtration can then be adopted with perfectly satisfactory results. A bill has been introduced in the Senate with this object in view but as yet no authority for its use has been granted.

The average turbidities, taken by months, as measured by the U. S. Geological Survey standard are shown in Table 1:

Table 1.—Turbidity of Raw, Settled and Filtered Water.

	Great Falls.	Dalecarlia Res.	Georgetown Res.	Wash. City Res.	Filt. Water Res.
Oct. ..	36	21	18	11	1
Nov. .	19	19	14	11	1
Dec. .	199	84	74	39	6
Jan. ..	94	60	60	52	12
Feb. .	45	41	29	22	3

The numbers of bacteria in the Potomac water are rather low and the efficiency of the filters has been uniformly satisfactory after having had time to ripen. The average numbers of bacteria per cubic centimeter in the water of the Washington City and filtered water reservoirs taken by months are given in Table 2:

Table 2.—Bacterial Counts.

	Washington City Reservoir.	Filtered Water Reservoir.
October	207	81
November	153	27
December	3750	55
January	1520	33
February	562	16

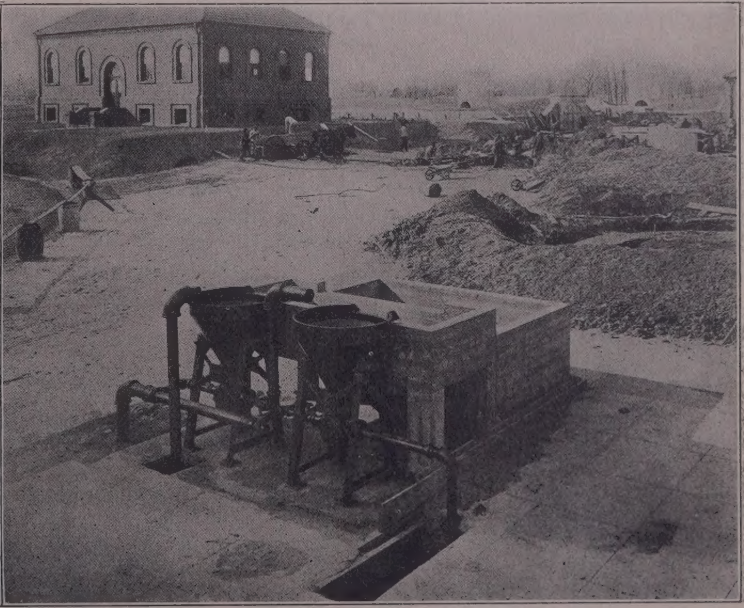
The length of runs has been quite remarkable, especially during the winter months, and is given in Table 3:

Table 3.—Duration of First Runs.

Filter.	Duration.	Quantity filtered.	Depth of scraping.
1	52 days.	153,000,000 gals.	1.00 in.
2	55	162,000,000	1.01
3	53	149,000,000	.92
4	55	165,000,000	.87
5	58	175,000,000	.87
6	41	119,000,000	.54
7	40	118,000,000	.59
8	50	149,000,000	.88
9	51	152,000,000	.81
10	..	..	..
11	118	386,000,000	2.64
12	38	117,000,000	.64
13	46	139,000,000	.62
14	54	158,000,000	1.04
15	43	129,000,000	.85
16	43	131,000,000	.66
17	43	129,000,000	.70
18	51	154,000,000	.95
19	58	172,000,000	.88
20	47	131,000,000	.71
21	50	137,000,000	.87
22	39	126,000,000	.73
23	40	129,000,000	.80
24	45	148,000,000	.74
25	41	117,000,000	.53
26	44	125,000,000	.59
27	..	..	..
28	47	160,000,000	.55
29	41	144,000,000	.74
Duration of second runs.			
1	48	170,000,000	.63
2	57	191,000,000	1.08
3	53	183,000,000	.88
4	74	239,000,000	1.97
5	81	278,000,000	2.26
6	..	..	..
7	48	155,000,000	.66
8	56	197,000,000	.81
9	64	219,000,000	1.39
11	..	..	..
10	..	..	..
12	90	303,000,000	2.16
13	104	307,000,000	2.54
14	122	322,000,000	2.23
15	..	..	..
16	137	376,000,000	..
17	122	354,000,000	2.38
18	128	339,000,000	..

Owing to the long runs, the cost for operating the plant has been very low, thus far being about $2 per million gallons filtered, which includes all labor and superintendence for cleaning the filters, courts and buildings, the laboratory and office force, and the pumping station force, as well as for all coal and supplies of every kind.

Constructing Sand Bins.



Sand Washing Station.

It may be well to add that the sand handling apparatus is not yet completed, and the courts are not paved. It has, therefore, been necessary not only to remove the dirty sand in wheelbarrows, but temporary runways have been built and the sand stored on the tops of the filters, which added very materially to the cost of operation. On the other hand, no sand has yet been washed or replaced in the beds.

As may be seen by Table 3, the depth of scraping is as unusually great as the length of runs, showing that the fine clay in the raw water penetrated the filter sand to a considerable depth.

The average daily quantities of water pumped to the filters, taken by months, have been as follows: Oct., 68,000,000 gal.; Nov., 66,000,000 gal.; Dec., 67,000,000 gal.; Jan., 65,000,000 gal.; Feb., 69,000,000 gal.

One of the largest items of expense in operating a slow sand filtration plant is the handling of the sand. In designing a modern plant, the engineer naturally gives this subject a good deal of thought in his endeavor to lessen operating expenses when it is put into service. Naturally, each engineer dealing with this problem sees its several phases in different lights, and there will doubtless be many solutions, each differing considerably from another, before it has been proved which is the best, and so becomes a standard design. The quantities of sand to be handled are comparatively small and spread out over large areas, so that heavy and expensive machines and appliances are inadmissible.

For the use of the Washington plant, the writer suggested elevated storage bins to which the washed sand is carried directly from the sand washers by means of water. This system has been adopted and part of the bins are now completed. Owing to some improvements in the sand washers, made by Mr. Allen Hazen, we expect to have no difficulty in washing the sand practically clean in one hopper of the ejector type of washer, completely washing it in the second as well as elevating it to the bins.

The proposed method of handling the sand, then, is to scrape the surface of the filter sand and throw it into piles by hand in the usual way. A portable ejector and pipe system are then used for transporting the sand from the piles to the washers with ejectors similar to those used at Philadelphia, but more powerful. The sand and water are emptied directly into the washers, from which the washed sand is carried by water from the second hopper of the washer into elevated storage bins. These bins are at such an elevation that carts may be driven underneath them and loaded by means of a gate in the bottom of the bin. It is then hauled to the tops of the filters and dumped through the manholes on chutes which may be revolved to discharge in any direction.

There are to be 29 sand bins for the complete plant, each having a capacity of 250 cu. yd. These bins are arranged in groups such that the combined capacity of the bins in a group will be sufficient to refill one filter when scraped to the minimum allowable depth.

They are built of reinforced concrete having a thickness of 9 in. at the top and 12 in. at the bottom of the cylindrical part of the bin proper; the conical part having a thickness of 15 in. In undisturbed ground the foundation is carried down 4 ft. below the surface. There are a good many cases, however, where the bins are located over one or more lines of pipes at various depths, and the foundations are then carried down to undisturbed material below the pipe lines, the concrete being carried up around the pipes leaving a clear space of 6 in. around them. The bins are built of two grades of concrete, one being considered as that supporting the bin proper, and the other that part actually containing the sand. The supporting part has only a small amount of steel and is made of concrete containing 1 barrel of Portland cement, 11 cu. ft. of concrete sand, and 19 cu. ft. of run of crusher stone passing a 2½-in. screen. The bin proper is of concrete containing 1 barrel of Portland cement, 8 cu. ft. of concrete sand, and 14 cu. ft. of run of crusher broken stone passing a 1½-in. screen.

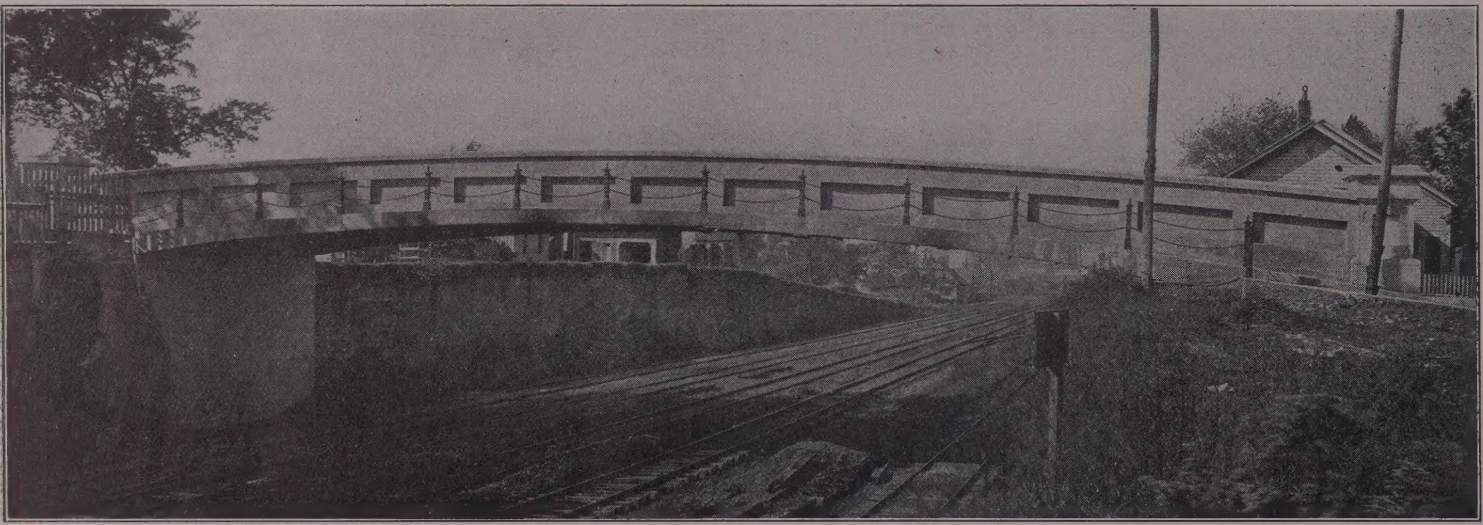
The amount of concrete in a bin proper is 64 cu. yd. in all cases. That in the supporting part varies between 81 and 120 cu. yd, and averages 109 yd. In computing the amount of steel in the various parts it was assumed that the mixture of sand and water acted as a fluid having a specific gravity of two, enough steel being used to sustain safely all tensile stresses. For all the hoops, plain round rods were used, otherwise they were square in section and twisted. In constructing the bins, the contractor was required to make the bin proper monolithic, which was accomplished by working continuously night and day until this part was completed.

A Transportation Problem of an unusual character arose when the cast-steel stern posts of the new Cunard turbine steamers had to be shipped from the works of the Darlington Forge Co. These castings were so large that they could not be loaded on a car in any way to keep them within the clearance lines, and this prevented their delivery by rail to the shipyards. They were accordingly sent by rail to Middlesbrough, which was possible by careful train operation, and sent from there by water.

A Flat Span Reinforced Concrete Bridge at Memphis.

A 100-ft. through span, reinforced-concrete highway bridge, carried by two longitudinal girders, without any dependence on arch action, has recently been built at Memphis, Tenn. The bridge replaces an old wooden structure and spans a 100-ft. right-of-way on which six tracks of four different railroads are laid. The railroad tracks closely parallel one side of a cemetery so that the approach to one end of the bridge is within the grounds of the latter, the level of the grounds being about 15 ft. above the tracks. Owing to the necessity of providing a clearance of at least 19 ft. over all of the tracks on the right-of-way, and to very strong objections to a slightly graded approach that would have been required in the cemetery grounds if an arched bridge which would provide such a clearance had been built, a practically flat span had to be designed and has been erected.

The span has a rise of 4 ft., but as may be seen from the accompanying reproductions of the plans and of a photograph of the bridge, this rise is largely introduced near the abutments. The two longitudinal girders are designed to carry the floor, which is also reinforced and is suspended from them. Each end of both girders is designed to act as a cantilever beam for 21 ft. from the abutments. Between the outer ends of the two cantilever parts of each girder the latter is designed to act as a simple beam, with a span of 58 ft. carried by the cantilevers.



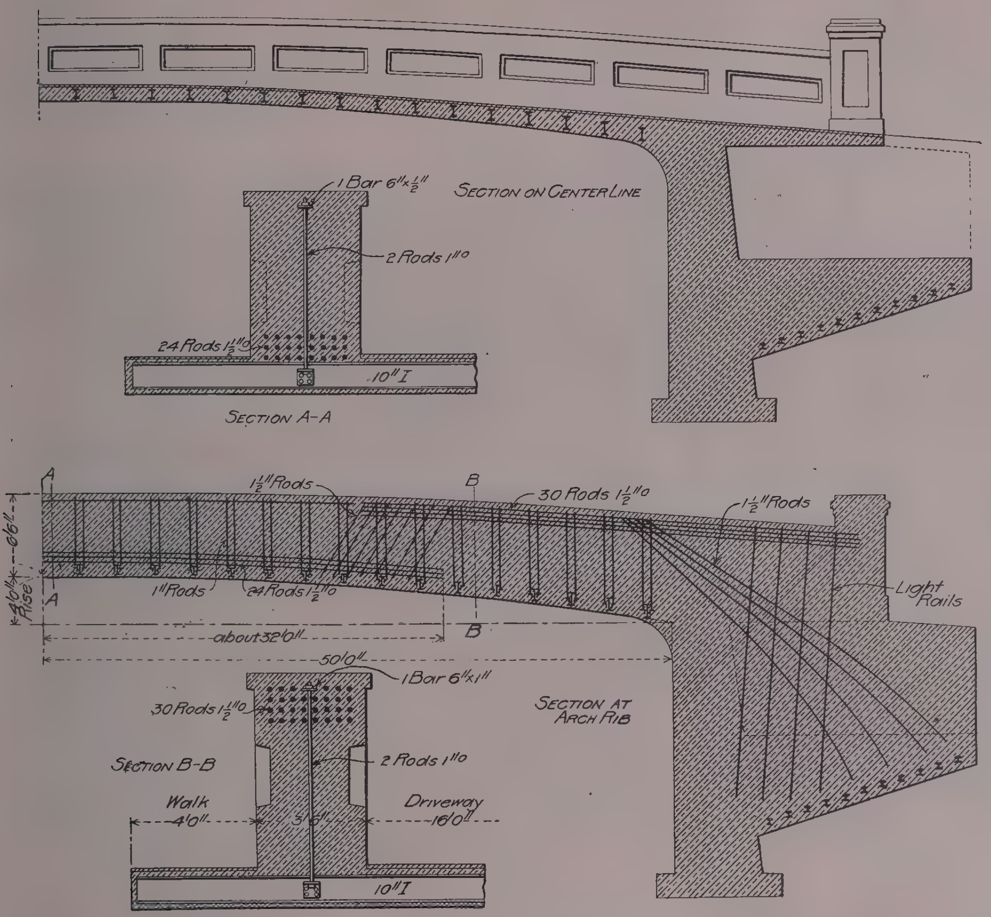
Reinforced Concrete Highway Bridge at Memphis, Tenn.

The bridge has a total width of 31 ft., made up of a 16-ft. roadway, with a walk on each side, one girder being between the roadway and each walk. The girders are 3 ft. 6 in. wide and have a total height of 6 ft. 6 in., including a 6-in. coping. The girders being designed to act as cantilevers toward the abutments, tension stresses are produced near their upper surfaces in this portion of them and the concrete has been reinforced accordingly. This reinforcement consists of thirty 1½-in. bars, placed in four horizontal rows as shown in one of the accompanying illustrations. These bars are 40 ft. long, extending 4 ft. beyond the outer end of the cantilever section of the girder and 15 ft. back into the end of the girder over the abutment. The simple beam portion of each girder is reinforced near the bottom by twenty-four 1½-in. bars in three rows. This reinforcement is 66 ft. long and extends 4 ft. into the outer end of each of the cantilever sections supporting the simple beam. Two planes of no moment occur in each girder, one at the junction between the end of each cantilever and the adjoining end of the simple beam.

Heavy shearing stresses are, therefore, introduced at these points. These stresses are overcome by thirty short, inclined 1½-in. bars placed in the vicinity of each of the planes of no moment.

Each cantilever is anchored to its abutment by a cluster of 1½-in. bars, which extend from a central point near the top of the girder and over the haunch of the arch down into the concrete of the abutment, radiating in the latter to secure more complete anchorage. Several light street railway rails were also placed in each girder back of the point of support to bond the masonry of the girder and the abutment together.

The abutments had to be designed to provide anchorages for the cantilevers, the thrust from the arch being considered of little consequence. The section of the girders is extended well back from the point of support of the cantilevers and down to the bottom of the abutments. Between the girders the abutments are hollow, having a retaining wall at the front, with a wide, flat floor cantilevered back from the rear face of the wall. This floor is reinforced near the lower surface with light rails, the ends of which extend into the girder abutments. The front wall thus retains an earth load on the floor and provides an additional anchorage.



Structural Details of the Reinforced Concrete Bridge at Memphis.

The bridge floor is 13 in. thick and is reinforced with I-beams placed transversely. Each beam is attached on the center line of both bridge girders to two 1-in. tie rods. These rods extend up into the girder and are anchored just below the coping on the latter to a longitudinal ½x6-in. steel bar imbedded in the concrete. The floor is thus suspended from the girders and is not designed to be self-supporting due to any arch action that may occur in it. It is designed to carry a uniform live load of 200 lb. per square foot. This load is small, however, as compared with the dead load of the bridge, amounting to 3 cu. yd. of concrete per linear foot of span, which the girders are required to carry.

The erection of the forms for the span was rendered difficult and expensive by the necessity of maintaining traffic on the six railroad tracks. The dead load of the bridge to be carried by these forms was approximately 1,000,000 lb. Spans of as much as 20 ft. were required in the falsework for the centering in order to clear the tracks. The bents of the forms were built of 12x12-in. timbers, heavily X-braced. Resting on the caps of these bents were 5x16-in. stringers, placed closely together, which carried the lagging.

The concrete was mixed fairly wet in the proportions of 1 of Portland cement, 2½ sand and 5 of small broken stone. Johnson corrugated bars were used for reinforcement, except as mentioned. One girder was built in a single day and the other the following day, each of the girders being considered as a separate structure during the construction. After the concrete had set 3 months the forms were removed without any settlement occurring, in so far as it was possible to discover. No cracks are apparent in the structure, except a very few small ones in the coping, which is not reinforced and has no expansion joints.

The bridge cost $17,500 complete, including the asphalt pavement on the roadway, a cut-stone veneer on the posts at the ends of the girders and the iron railing along the walk on each side. The forms required $4,000 of this amount, owing chiefly to the difficulty of erecting them so they would not interfere with traffic on the tracks. The girders and the floor of the span contain about 200 and the abutments 800 cu. yd. of concrete. The latter quantity could be greatly reduced in proportion to the former in a structure with several spans of the same type, since the reinforcement at the top of the cantilever sections of the girders could be extended through adjoining spans and the heavy anchorage required in a structure with a single span avoided.

The bridge was designed by Mr. J. A. Omberg, Jr., city engineer of Memphis, and was built under his direction by the regular forces of the city.

Cost of Canal Excavation Through Peat and Soft Material.

In the construction of the Hennepin Canal near Wyanet, Ill., a Lidgerwood duplex traveling cableway of special design has been used with excellent results in excavating peat and other soft material. This work was described in this journal on Feb. 10. It is under the charge of Lieut.-Col. W. H. Bixby, Corps of Engineers, U. S. A., and is under the direct supervision of Mr. Joseph Wright. He recently made a report on the work to Col. Bixby, explaining what was accomplished by the plant, omitting such costs as properly belonged to special drainage work, bank slides and other troubles not due to the fault of the dredge. These figures cover the period from Oct. 10 to Dec. 20, 1904, and were chosen as being more nearly representative of what might be expected of such a plant working in soft material under normal conditions, provided allowance be made for extraordinary breakages and renewals. Through the courtesy of Col. Bixby this report is given below. The main figures are as follows:

Span of cableway	525 ft.
Average length of hauls	200 ft.
Distance advanced each day by cableway, about	70 ft.
Material excavated	peat
Capacity of dippers used, nominal	1½ cu. yd.
The number of buckets handled each day was registered by the bell boys.	
Actual average dipper load, place measure	1.77 cu. yd.
Total operating cost, Oct. 10 to Dec. 20	$11,546.10
Total yardage	131,414 cu. yds
Operating cost per yard	8.78 cents
Total cost of labor	$7,260.79
Repairs, renewals, lubricating oil, kerosene oil for Wells lights, waste, etc.	$3,527.82
Coal	$757.49

The above figures were taken from Mr. Wright's books just as they stand. It will be noticed that the item for repairs, oil, etc., is quite large. This item includes $1,350 worth of new cables, whereas only about one-third of it should properly be charged to the operating cost for this period. The kerosene oil bill for lights was about $293.50 or about $126 per month. This, of course, is a proper charge if operated 24 hours per day, as was the case.

Cutting out such items as should not have been charged to operating cost during this period, but which should have been carried as unexpended to a later period, there is an aggregate of $1,793.12 which should properly be deducted from the "repair" item above. Making this deduction reduces the "total operating cost" to $9,752.98, and the "operating cost per yard" to 7.42 cents.

It is only fair to state in this connection that during the period of operation for which cost data are submitted the towers were moving over very soft ground. This made the track work expensive and was the cause of a number of extraordinary breakages. Then, too, three crank shafts of the cableway engines were broken and renewed during this period, due to the engines having been provided with unsuitable foundations when installed. The cost of the new shafts has been included in the deduction made above, but the cost of the delay occasioned has not. The engines were taken up and re-bedded during the winter of 1904 and 1905, and since have given no trouble by breaking shafts or heating of journals.

Numerous other improvements, renewals, etc., were made at the same time among which was the substitution of 2-in. patent locked main cables for the old 2¼-in. rope cables. This change alone resulted in the saving of $180 per month on carriage sheaves during the season of 1905, and much better results could have been shown during 1905 than for the period chosen had other conditions been the same.

The data referred to in The Engineering Record for Feb. 10 hardly does justice to the machine, in Mr. Wright's opinion, in comparison with other machines for similar work in that it includes the cost of a large force of ditchers employed during the entire year, and the extra expense entailed by the necessity of having to move across the slough four times instead of once; i. e., the material was so unstable it was necessary to partially excavate the cut in passing over it the first time, ditch it, let it dry, and then pass over it again, repeating the process until the cut was excavated to grade. Then there was the cost of widening the span from 525 ft. to 625 ft., and many other things which, while properly charged in the records, it is unfair to charge to the cableway when compared with other excavating machines.

During the period for which data are submitted in these notes the cableway was passing through the slough the first time and the cut was being excavated from 8 to 10 ft. deep. The rate of track laying was about 70 ft. per day. Had the cut been deeper the output would, of course, have been somewhat larger, and the labor account on track work materially smaller.

The operating force required, and the wages paid were as follows:

1 Engineman, per month	$125.00
Who had charge of the machinery, and who slept on the ground, took his turn at the operating levers for 8 hours each day, and who was subject to call at any time in case of a breakdown.	
5 Enginemen (8-hour day) per day	4.00
6 Firemen (2 for each shift) per day	2.50
3 Riggers (1 for each shift) per day	2.00
3 Pumpmen (1 for each shift) per day	1.60
2. Light-tenders (1 for each night shift) per day	1.60
2 Signal men (2 for each shift) per month	45.00
1 Foreman (day shift only) per month	75.00
12 to 16 Laborers (day shift only) per day	1.60
2 and sometimes 3 teams (day shift only) per day	3.50

The above list constituted the operating force, but in addition a part of the salaries of junior engineer ($150), surveyman ($60), timekeeper ($60), locomotive engineer ($90), and fireman ($60), (locomotive used to haul men, coal, supplies) and blacksmith ($2.50), proportionate to the relative cost of the cableway operation to that of other work in progress on Miles 19 to 22, inclusive, was charged to the labor account of the cableway.

Nothing was allowed for interest and depreciation, but the plant cost complete and in operation $28,580.15, and a proper charge for depreciation could be arrived at when the yardage to be handled on a particular job is known.

The Croton Dam.

The accompanying illustrations of the Croton dam give a good idea of the appearance of its downstream face at the present time. Although the design and method of construction of the dam have been subjects of many articles in this journal, it is appropriate, in view of the recent official acceptance of the structure from the contractors, to point out its leading features. It crosses the Croton River about 6 miles from its mouth and 35 miles from New York. Above this lowest dam are 10 large dams, besides several secondary dams or dykes, and one large dam in course of construction. Designs for a great dam across the Croton at Quaker Bridge, or the Cornell site, were studied as early as 1882. The Cornell site, about 1¼ miles above Quaker Bridge, was finally chosen, and construction begun in September, 1892.

The new Croton dam is the highest and largest masonry dam in the world, containing 850,000 cu. yd. of masonry. Only about one-half the height of the main part of the dam appears above the ground, and, roughly, two-thirds of the mass of this portion are below the earth's surface. Approximately 1,750,000 cu. yd. of earth and 425,000 cu. yd. of rock excavation were required. The reservoir is nearly 20 miles long, and its total contents when full are about 38,000,000,000 gal., of which ordinarily 20,000,000 gal. are available. Over 32 miles of new highways and 21 steel bridges have been built in connection with this new reservoir. A county highway traverses the top of the dam and is carried over the waste channel on a 200-ft. steel arch. Nearly 75 miles of stone walls enclose the land required for this reservoir. When the new reservoir is full, the Old Croton dam, about 3 miles above the new dam, will be submerged to a depth of 34 ft.

A short distance upstream from its middle the New Croton reservoir is very narrow, and above this place the water is shallow over large areas, even when the reservoir is full. Consequently the Muscoot dam has been built here to hold the water at full reservoir level ordinarily. In emergency this upper basin can be drawn down through a gate house in the dam. The overfall of the dam is 950 ft. long, and all the natural flow of the river and the water drawn from the reservoirs above will pass over it.

A large gate house, finished about 1890, at a cost of nearly $750,000, situated just below the Old Croton dam, controls the flow of water into the Old and New Croton aqueducts, through which it flows to the city. The old gate house controlling the old aqueduct is submerged by the new reservoir, and consequently has been partially dismantled. The old aqueduct has a capacity of about 80,000,000 gal. daily, was completed in 1842, and is approximately 34 miles long, 2 miles of earth and 2 miles of rock tunnels and 30 miles in trench or on embankment. Its interior dimensions are 7½ ft. wide by 8 ft. high, area of cross-section about 53 sq. ft., and its slope 13¼ in. per mile. For most of its length it has an 8-in. brick arch, a 4-in. brick invert on concrete and rubble side walls, lined with one course of brick. Its total cost, including land, was $12,000,000. Between the old and new dams, the old aqueduct, being in the new reservoir, has been strengthened and the parts on embankments replaced by loops following the contour of the hillside on natural ground.

New Croton aqueduct, nearly 31 miles long, is almost wholly in deep rock tunnel, only a little over 1 mile being in trench or on embankment, and terminates at the 135th Street gate house, near the northerly end of the main part of Manhattan Island. Old Croton aqueduct has also been connected into this gate house, and from this place water is conveyed to Central Park distributing reservoirs and various points of connection with the pipe system through eight 48-in. cast-iron mains. For about three-quarters of its length the new aqueduct has a horseshoe cross-section 13.6 ft. wide and 13.53 ft. high, maximum inside dimensions, with an area of 154 sq. ft., and a slope of 0.7 ft. per mile. The lining is brick, with brick or rubble backing, mostly. Gould's swamp siphon is circular, 14.25 ft. in diameter, 1,135 ft. long. For 36,080 ft., from a point north of Jerome Park reservoir to 135th Street, the aqueduct is under pressure, and circular, being 12.25 ft. diameter, excepting the 1,300 ft. under the Harlem River, 10.5 ft. diameter. The maximum capacity of the aqueduct when clean is about 300,000,000 gal. daily. The new aqueduct was first put into service July 15, 1890, and was transferred to the Department of Water Supply, Gas and Electricity, June 24, 1891. Its total cost, exclusive of land and engineering, was approximately $20,000,000. In its construction 2,250,000 cu. yd. of earth and rock were excavated, and 904,000 cu. yd. of masonry built.

During the past 18 years the flow of the Croton River has been 30 per cent. greater, on the average, than for the preceding 18 years, 1869 to 1886, and 11½ per cent. greater than the average for 37 years. In 1901, 1902 and 1903 the

View Looking North, Croton Dam.

View Looking South, Croton Dam.

flow was excessively high. These facts have masked the necessity for further works to meet the consumption in a series of dry years, which may occur at any time.

The chief engineers of the New Croton works have been successively Benjamin S. Church, Alphonse Fteley, William R. Hill, J. Waldo Smith and Walter H. Sears. The new dam was built by Coleman, Breuchaud & Coleman, and the gates, valves and other iron work were furnished by the Coldwell-Wilcox Co.

The Cost of Brick Pavement in Helena, Mont.

By Charles W. Helmick.

Main St., Helena, was laid out on what was once an old placer mine and remains of the old timbers used in mining were found in excavating for renewing water and other pipes. An old bored-log water main laid in 1864 was dug up in places, and where the ground was moist, the wood was in a good state of preservation, having decayed but very little. Some of the old flume posts projecting slightly above sub-grade were only crushed and not broken off by the passage of a 12-ton roller over them. Last Chance was one of the noted gulches of Montana, fully twenty million dollars' worth of placer gold having been washed from its auriferous gravel and sand. Even at this date gravel and sand are sometimes found in excavating for basements of the larger buildings, rich enough to pay well for the washing, if it were in some other place than the heart of the city.

Stairway to Blow-off Chamber and Gate House, and Bridge over Spillway.

The ground having been worked over one or more times in mining, was not suitable for the foundation for a pavement, as was evidenced by the sinking of the preceding wooden block pavement which had a 7-in. macadam foundation. The city therefore decided to have the wood blocks removed, together with as much of the macadam base, as would be necessary to get the proper sub-grade, and to replace it with a vitrified brick pavement on a 5-in. concrete foundation. In April, 1905, the city accordingly entered into a contract to pave Main St. from Cutler St. to Helena Ave. with vitrified brick upon a foundation as above specified. The total area of the pavement is 18,457 sq. yd. By the terms of the franchise of the Helena Light & Traction Co. it was to pave the space between the rails and for one foot outside. This area was 7 ft. wide where single track was used, and 14 ft. wide where there were two tracks. The net amount paid for by the city was 13,900 sq. yd. The work for both the city and traction company was done by the same contractor.

The cost to the city, excluding engineering, was $43,700, or an average of $3.15 per square yard. Unit prices paid for the principal items were as follows: Brick pavement, including the spreading of the sand cushion, $1.79 per square yard; concrete, $5.75 per cubic yard; excavation, 65 cents per cubic yard; rolling roadbed, 10 cents per square yard; removing old blocks, 2 cents per square yard; filling joints, 20 cents per square yard. The actual cost of rolling was about 3 cents per square yard, while it was worth about 8 cents per square yard to remove the old blocks.

The concrete was made in the following proportions: 5 bags of cement, ½ cu. yd. sand, 1 cu. yd. of crushed stone, the last two measured loose. It was mixed on water-tight wooden platforms. A concrete crew consisted of one foreman and six assistants. A batch of concrete consisted of 3⅓ bags of Portland cement, 9 cu. ft. of sand and 18 cu. ft. of broken stone, crusher run. Such a batch, when rammed in place, made on an average 20.5 cu. ft. When the materials did not have to be hauled over 50 ft. a crew would average 24 batches per day.

The bricks were made from a shale within the city limits and were of ordinary size, so that 58 bricks laid one square yard of pavement. They cost $20 per 1,000 delivered. A paving crew consisted of two pavers, three carriers, and two boys who laid the shaped bricks along the car tracks and whose work was fully equal to the labor of one man. Where there were two tracks, each paver averaged 6,500 bricks per day, where there was one track 10,400 per day, with an average of 7,900 per day for the entire work.

There were two men at work for 60 days forming the sand cushion for the City and Traction Company. Probably 45 days of their time was for city's part. After the bricks were laid and before the joints were filled, the pavement was rolled with a 2-ton horse roller made expressly for this purpose. The average amount rolled was about 80 sq. yd. per hour. The roller was 26 in. long and cast with a square edge. This square edge crushed a good many bricks in turning, so the defect was remedied by turning the edge round.

The portion of the pavement between the curb and railway track was filled with a coal pitch filler at first equal parts of pitch and tar, boiled until the mixture quit foaming, were used. The amount of pitch was entirely too great, as the filler seemed to harden too rapidly and would stick to the top of the bricks instead of running into the joints. A better filler can be made of 1 barrel of pitch to 3 barrels of tar. Boil the latter for about 5 hours, add the pitch and boil until the proper consistency is reached. This can be ascertained by dipping in a brick and noticing when the coating is hard and tough but not brittle when cold. An ordinary window washer with a piece of heavy rubber belting securely fastened in the slot, makes the best tool for spreading the filler.

It was impossible to segregate the time actually spent on this filler from that spent on both the tar and grout filler, which was about 66 days for three men, including the boiling. The cost of filling the joints with tar filler was about 21 cents per square yard, and with grout about 14 cents.

In all city contracts eight hours labor constitutes one day's work. The prevailing wages for work per day were as follows: Bricklayers, $6; helpers, $3 (later, $7 and $3.50, respectively); concrete foreman, $6; helpers, $3; men on sand cushion, $3.50; men filling joints, $3; ordinary labor, $2.50; man and team, $5.

Sand cost 80 cents and crushed stone about $1.25 per cubic yard delivered. The laying of the brick, not including the sand cushion was sub-let at $1.92 per 1,000, or 12 cents per square yard.

This pavement was put down substantially, and thus far has given universal satisfaction. In 1898 1,000 sq. yds. were laid on Sixth Ave. adjoining Main St., in the same manner except with a sand filler. It has never had any repairs, and is in good condition to-day. The bricks show but little wear and that on the edges only.

Municipal Ownership was partly approved by the voters of Chicago on April 3. The proposition to operate the street railways by city employees was voted down; there were 120,911 affirmative and 110,260 negative votes, but as three-fifths' vote was necessary to carry the proposition, it was lost. The vote to issue bonds to an amount not exceeding $75,000,000 for the purchase and improvement of the street railway systems of the private companies was carried by about 3,800 votes. It is understood that the mayor is disappointed in the refusal of the people to authorize the city to operate the lines, for he does not agree with the famous report of his adviser, Mr. Dalrymple, of Glasgow, that the American system of popular government as now conducted renders the public management of undertakings employing large numbers of men inadvisable.

An Unusual Floor System in a Car Repair Shop.

The new repair shop of the Philadelphia Rapid Transit Co. is of somewhat irregular shape, about 570x290 ft. in extreme dimensions and consists of several rectangular one-story structures with parallel sides which are practically continuous, so that the group forms one large building including the inspection, machine, jacking up and miscellaneous repair shops, store room and offices. All of them have concrete floors and roofs and brick walls; the roof of the 69x112-ft. store room has concrete beams supported by concrete columns; in the other buildings the roof has steel beams and steel columns. The site of the building is partly on a marsh and partly on a side hill, and the floor being at a uniform level throughout was carried below the original surface of the hill-side and above that of the marsh. As it was not practicable to fill the marsh up to the floor level immediately, the design was made with special reference to filling in after the completion of the building. For this reason and on account of other considerations, the construction was entirely of concrete up to the top of the floor, above which the side walls are built of brick and glass with a steel frame-work supporting the roof except in the store room wing.

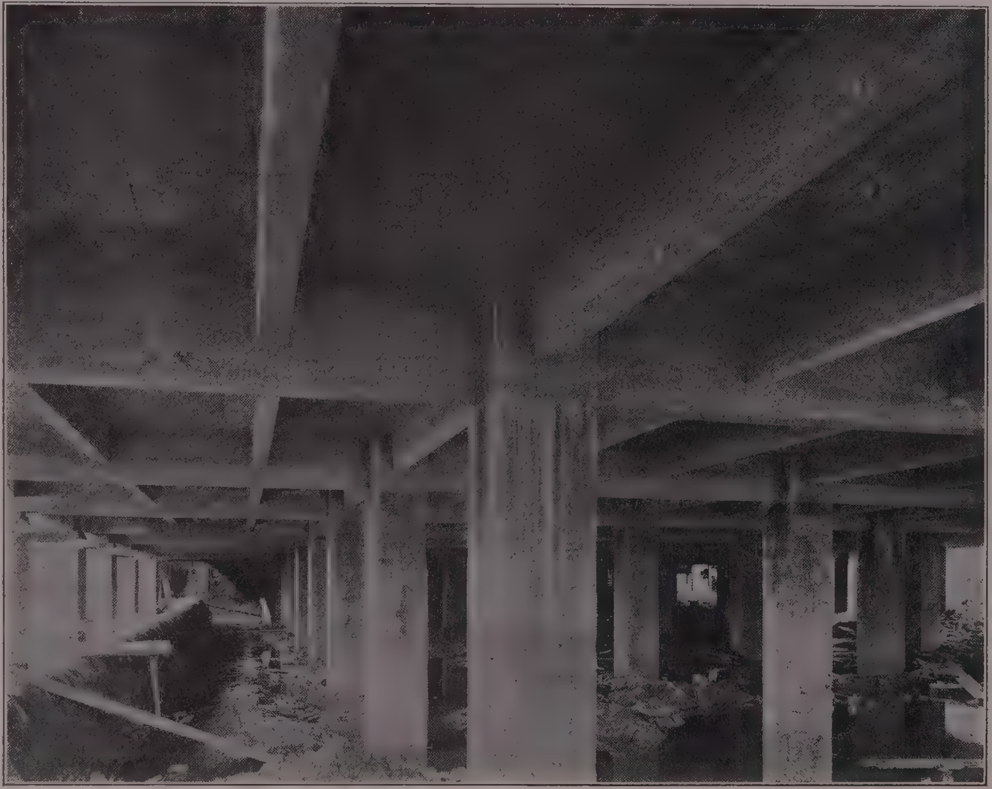
The substructure consists of concrete piers without steel reinforcement from 16 to 22 ft. apart and carried down in sheeted pits to rock at a maximum depth of about 8 ft. below the surface of the marsh. The piers support reinforced concrete beams which vary from 6x16-in. with four 1-in. tension bars to 10x26 in. with nine 1¼-in. bars. They carry a slab from 4 to 6 in. thick, which is reinforced with 5/16-in. transverse rods from 4 to 6 in. apart on centers. The slab and beams are calculated for a live load of 150 lb. per square foot. Shearing stresses are provided for by vertical members of the De Valliere system, spaced according to the requirements of the shear diagrams. These members are each made with a 5/16-in. bar bent 180 deg. at the center and the two parts twisted together, their lower ends being looped around the tension bars in the bottom of the beam. This locates the steel in the center of the beam and is considered an important feature of the construction.

Transverse expansion joints are provided in the roof and floor about 80 ft. apart, and at each of them there is a double beam with a clear space of about 1 in. between its two halves. The floor slabs overhang the beams about ½ in. leaving a close joint between adjacent edges. Through all the shops there are longitudinal tracks, 14 in all, which are elevated 5 ft. above the surface of the floor. Their rails are spiked to 6x12-in. longitudinal timbers bolted flat to reinforced concrete girders which, together with an intermediate in each case, carry reinforced concrete platforms between all of the tracks.

The concrete roof slabs 4 in. thick are reinforced by 5/16-in. rods 6 in. apart and in the store room are carried by reinforced concrete beams similar to the floorbeams but having spans of from 22 to 36 ft. They are proportioned for a live load of 30 lb. per square foot. In the other shops the roof slabs are carried by steel I-beam purlins enclosed in concrete made integral with the slab and supported on steel trusses generally 16 ft. apart. The columns have a rectangular cross-section reinforced by four 1-in. vertical rods tied together every 12 in. They are proportioned for a maximum load of 500 lb. per square inch on the concrete. No compression is figured on the steel rods. The exterior columns are of concrete enclosed by brickwork integral with the curtain wall.

The foundation concrete is made with 1½-in. broken stone and is proportioned for a load of 15 tons per square foot on the surface of the rock. All other concrete is made with stone which will pass through a ¾-in. mesh and be rejected by a ¼-in. mesh. It is made very wet, with Vulcanite Portland cement, and is proportioned for extreme fibre stress of 500 lb. per square inch in beams and slabs. The reinforcement consists entirely of plain round bars of steel having an ultimate strength of 65,000 to 70,000 lb., and forming about 2 per cent. of the total cross-section of the beam.

All the molds and centering were built in place as required, no special construction and no knock-down forms being used. All molds were made of yellow pine dressed on one side and having square edges. The beam and column molds were made of 2-in. stuff and the floor and roof slab molds were neither greased nor lined, but when stripped left a smooth and uniform surface on the concrete. Owing to the large and irregular area of the buildings it was not considered desirable to install any central system of storage or concrete mixing, and the materials were delivered and stored in piles as required for different parts of the work. Two steam-driven Smith concrete mixers were set up on opposite sides of the building and were moved from place to place as the work advanced, so as to limit the distance to which the concrete was transported from them. These machines discharged directly into small storage bins from which the concrete was delivered through chutes and gates to two-wheel carts with a capacity of 8 cu. ft. These carts delivered the concrete and dumped it into position as required. For the column and roof work they were hoisted on hod elevators and then rolled to the required position on top of the roof slab molds. A maximum force of about 75 men were employed on the work, but progress was seriously delayed by interruption due to a strike on the structural steel contract. Mr. W. S. Twining, is chief engineer of the Philadelphia Rapid Transit Company, Mr. R. C. Heath, architect, and Mr. C. C. Anderson, superintendent for the Traction Company. The reinforced concrete work was designed and executed by the Reinforced Cement Construction Co., of New York and Philadelphia. The floors were finished with 1 in. of granolithic applied, as the floor slabs were made, by the Vulcanite Paving Co., Philadelphia.



Underside of Shop Floor.

Notes on Hydro-Electric Power Plants.

The two factors of prime importance in hydro-electric plants are reliability of service and commercial considerations, according to a paper presented recently to the American Institute of Electrical Engineers by Mr. David B. Rushmore. Reliability of service may be obtained from a system all of the separate parts of which do not possess this characteristic; but if the supply of power is unreliable, the sale of power is impossible and no commercial considerations will exist to be considered.

Duplication of apparatus and isolation of troubles, combined with the best construction and protective devices, are the principles employed to obtain continuous operation. Additional security is gained where a number of power stations feed into the same transmission network. In such instances any power house in trouble can be cut off entirely. Steam auxiliaries at the receiving end, supplying part of the load while floating on the system and possessing large overload capacities, as used at Los Angeles and Schenectady, are insurance against disabilities from line troubles.

The modern tendency is decidedly in favor of transferring the charges for maintenance and repairs to the interest column, by adopting more expensive construction with greater margins of safety. This is shown by the substitution of tunnels for flumes and ditches, and of steel towers for wooden poles, which is well illustrated in the new Kern River development of the Edison Electric Co., of Los Angeles, where the length of tunnels is three-fourths of the distance over which the water is carried; and, in a country particularly adapted for use of wooden poles, the line is to be carried 115 miles on steel towers. The factor of safety in insulators is also wisely being raised.

The number of plants to the system and the distribution of plants on different watersheds materially affect conditions of design and operation. A single plant with all the power transmitted to one place represents the most severe conditions; many plants, widely separated, on different watersheds, with steam auxiliaries and widely distributed use of power, the most favorable so far as load conditions are concerned. The type of construction is different for high and low heads and for few and many units. A peculiar feature of high-head building construction is the omission of openings on the hill side to provide for breaks in the pipe-line which sometimes, though very rarely, occur. The class of service has an important bearing on the system of control. Where conditions of contract do not severely penalize trouble, much simpler arrangements can be used than where it is demanded that no expense be spared to insure against interruptions.

Commercial loads—nearly always mixed in character—can be divided into railway, lighting, general power, pumping, hoisting, and electrolytic. These have seasonal, as well as hourly and daily, variation. Railway and lighting loads are particularly subject to abnormal variations from unusual causes. Both have large peaks over certain hours, and for a part of the day approach zero load. General power-load has an even curve for nine or ten hours with light load at noon, and is then off entirely or very light. A pumping load may be very steady and continuous over the day. During some seasons the pumps, if employed for irrigation work, may be out of use entirely. Fire pumps have a great and unknown load variation, but are seldom used but as part of larger loads. Hoisting loads are extremely variable in themselves, but the effect on the system may be smoothed out by use of a large number of hoists, or by the proper adaptation of fly-wheels and methods of control. Electrolytic loads are ideally constant at all times. Machinery must be installed to carry the peaks; and the determining of the best methods of meeting large load variations Mr. Rushmore considers the problem of prime importance in designing water power plants.

Elevated Floor Platforms between Track Pits.

Stream-flow varies greatly by the day, season, and year, but over a number of years it averages nearly constant. The curve of stream-flow, especially minimum flow, is of prime importance in water-power development. For considerations of storage, the load-factor of stream-flow has a vital bearing on the amount and cost of development. The great problem of hydraulic development is to transform the stream-flow to correspond to the load curve.

The design of different elements is determined by various limits, some of which are but indirectly connected with the load-factor. Water conductors should primarily be of sufficient capacity for the worst conditions—not always the case. The grade of ditches may vary from 40 ft. per mile for small ones, to 10 ft. or less per mile for large, the allowable velocity depending on the soil. Velocities should be sufficient to prevent the growth of vegetation in ditches, but not sufficient to cause erosion.

The capacity of water for carrying sediment varies as the sixth power of its velocity, and small decreases of velocity cause deposition of suspended matter, a fact made use of in sand boxes. With large quantities of water, it may be cheaper to replace wheels occasionally rather than to remove sand. In one Western plant, after a storm, the diameter of a nozzle was cut from 3.5 to 4.5 in. in an hour by sand.

Erosion wears away the ditch, with a possible loss of 20 per cent. or more in seepage through a stony bottom. Washes frequently break an embankment, the most annoying and expensive repairs to make. Three ft. per second is the average figure in many Western ditches; and 2 ft. is necessary in some fine soils. This figure is subject to much variation. Ditches, as actually constructed, are usually in exposed places on the sides of steep mountains; they are costly to build and difficult to repair, and the velocity of erosion is a limiting feature. It is estimated that California possesses over 5,000 miles of ditches, most of them constructed originally for hydraulic mining. The plant at Electra has two ditches of 21 and 19 miles length.

Velocities in flumes may range from 8 to 20 ft. per second; one flume about 9 ft. wide has a fall of about 7 ft. per mile; another 6 ft. wide has a grade of from 8.5 to 17 ft. per mile, depending on the length of section. Tunnels, when lined with concrete, may have a friction-coefficient of from 0.010 to 0.012. The complete cost may vary from $5 to $6 per cubic yard, or from $20 to $30 per lineal foot, for a 9-ft. tunnel. The coefficient of friction with rough rock walls will be from 0.030 to 0.035. For lined tunnels, 12.5 ft. per second is given as a conservative velocity. Velocities much higher are in use in short lengths.

Velocities in pipe lines are limited by considerations of cost, efficiency, safety, and regulation. They vary from 3 to 15 ft. per second. Wooden pipes with low velocities are often used at the upper ends, but the greatest loss of head should occur at the bottom in the most expensive pipe. The thickness and factor of safety used increase with the head.

For ocean freight, pipe lines should taper to allow proper packing by nesting. Cast iron pipe is never now installed, although in use in a number of early plants. For all high pressure work, riveted sheet-steel pipe is now universally used.

The best type of wheel to be used depends upon the head, quantity of water, speed, and range of load. Turbine wheels are efficient through only a small range of load, and under high heads are not easily regulated. In general, with low heads, large quantities of water and a number of generators to the plant, turbines are used. For small quantities of water, high heads, variable-head impulse-wheels are employed. Improvement in light load efficiency and some reserve against breakdown may be obtained by mounting impulse-wheels on both ends of the generator shaft.

The use of impulse-wheels of the Pelton type is limited by certain features of design. The center of buckets should run at about 45 per cent. of the spouting velocity. The diameter of the wheels should not be less than 10 times the diameter of the jet, and this ratio should preferably be 15 to 18. Also, the number of buckets which can be mounted on the rim has an important bearing. The limiting speed of turbine wheels is not so clearly fixed.

Turbine wheels are more flexible in design and present tendencies toward high speeds; and large units, as well as their application to higher heads, are having marked effect upon their development. The best type of wheel for a particular installation is not always self-evident. The use of vertical or horizontal types is still a matter of discussion and, under the same conditions, both types are installed, as at Niagara. Horizontal bearings for large high-speed units become abnormal, and certainly the step-bearing has proved its reliability on the steam turbine. Impulse-wheels may be used with vertical shafts and a number of nozzles applied to one wheel. The Necaxa plant in Mexico is an example of this construction.

Vertical shafts give a better operating room, requiring less space; generators and frequently wheels also are cheaper; bearings are simple and, with single wheels, have many attractive features. Small units, or units where impulse-wheels are used, are generally horizontal.

The number of water wheels to use with one generator is often a problem in low-head installations. With horizontal units, one or two impulse wheels may be used and any even number of turbines. Fluctuating heads are always turbine propositions and, as one design of wheel can at a given speed work efficiently through only a limited range in head, a number of wheels on the same shaft, for use at different times, may be necessary. Overloads can be carried by using the other wheels though inefficiently. The character of the load needs consideration in this regard.

Water-wheel generators have always been designed for 100 per cent. increase in speed, which Mr. Rushmore considers an unnecessarily conservative figure. In certain types of plants, subject to line disturbances, generators not infrequently run away; 63 per cent. increase in speed has been recorded in some cases. Of course this value depends upon the characteristics of the particular unit.

For large developments the selection of reservoir sites and capacities requires special investigation. Often several main reservoirs check the river flow, and a regulating reservoir at the head of the pipe line gives constant ditch-flow and carries the load temporarily in case of accident to the water supply. The cost of storage increases at high heads and often decreases at low heads for increasing capacities. If great fluctuations in stream-flow obtain, it is seldom possible, from a commercial standpoint, to store all the water. Where development exceeds minimum stream-flow, there are but few high-head propositions where storage is not desirable; conversely, in many low-head installations the cost of storage is prohibitive.

Erosion in ditches and loss of head in pipes are the usual limits of their design. For flumes there is a grade for maximum capacity which, if exceeded, decreases the amount of water that can be carried, by causing a wave motion. The loss of head at maximum load is important. High velocities, and rapidly varying loads, make regulation difficult. A subdivision of the pipe-line is desirable.

The size of the generator is usually indicated by some conditions in the proposition. The loss of one unit should not cripple the service. The generators and wheels should operate at points of best efficiency. The generator and wheel combinations are limited and speeds are fixed by number of wheels, type, head and output. For one-plant systems the number of generators is preferably not less than four nor more than eight, according to Mr. Rushmore. For multiple-plant systems, one unit to the station is not uncommon.

When no strong reasons exist for doing otherwise, water-wheel driven generators should have a rating of 40° Cent. rise at full load and 8 per cent. regulation. This agrees with a wheel rating for 4/5 gate. A greater approach to standard in this is very desirable. This allows for 25 per cent. overload on peaks. There is no reason for a higher generator rating if the capacity does not exist in the wheel. A small margin—about 10 per cent. of gate—should be left for governing. The above is for a number of units and a time variation of load not greater than can be cared for by placing in operation additional units. For suddenly-varying loads and peaks over short intervals, it may be desirable to have a wheel rating of 100 per cent. in excess of generator. The greater the number of units, the smaller this need be. In some cases it is desirable to take the peaks on a part of the station and to block the governors on the remaining machines. Transformer ratings are usually the same as generator, and, when possible to do so, it is often desirable to make one unit of the two.

Generators for a given output have a speed for which the cost is a minimum. Unless peripheral velocities are increased, raising the speed does not decrease the active material. So, when this point has been reached, any further increase calls for mechanical requirements which rapidly increase the cost. Water wheels, within the limit of generator speeds, decrease in cost with increasing speeds.

Most transmission lines are designed from a standpoint of regulation, but occasionally a case arises where an application of Kelvin's law is possible. For low-head factors, average losses may be used. A large number of equations have been developed for this work but an equality of interest on investment and value of lost energy is what is required. Unless maximum developments are installed, ample margins in all hydraulic and electrical conductors should be allowed for future growth.

The cost and value of efficiency in power plant designing is an important but not clearly understood subject. The rough approximation usually made is to compare the selling price of the increased output with the interest charge on the greater cost. Where the saving in energy can be sold, as is usually the case, a higher efficiency in water conductors means a greater output and a greater capacity of installed apparatus with higher total cost, so that the investment charge for the gain in power is greater than usually considered. This is true of all parts of the chain of energy transformation.

Generator efficiency curves are flat beyond half load and are generally slowly increasing at overloads. Above half load, variation in generator efficiency is not of importance. Turbines have, however, a small range of load for best efficiency; while the curve for impulse-wheels is much flatter.

The cost of efficiency is less susceptible of determination than the value. Water wheels can be made of the best efficiency by designing them for the special conditions, instead of using standard patterns, and by the employment of a high grade of material with careful finish. The life can be increased by use of expensive metals and by cleaning the water. Wheels probably differ in efficiency much more than electrical apparatus.

With a limited water supply, storage of water determines the possible development. Variations in load occur by the hour, day, season and year. Auxiliary or regulating reservoirs at the head of the pipe-line take care of daily peaks, keep an even load on the water conductors, and serve to carry the plant over temporary ditch troubles, also serving as sand boxes. The location of the pipe-line often renders storage at this point impossible. In one case, a flume of large dimensions is used for peak storage. In another, the water supply to a flume several miles in length is cut off entirely and the total stream-flow used for another station.

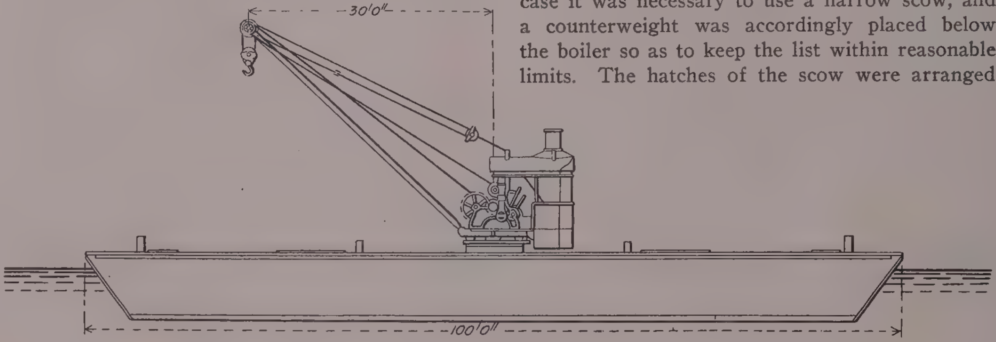
For suddenly varying loads, as in railway and hoisting work, a fly-wheel is used to provide for instantaneous peaks. Irrigation laws may forbid the storage of water on old ditches. Electrical storage, at the distributing points, bears to the electrical system the same relation that the regulating reservoir does to the hydraulic.

The capacity of a water-power installation can usually be largely increased by the use of steam auxiliary plants. A steam plant can supply the deficiencies of stream-flow, can carry peaks in any season. It may act as a regulator with steam turbine floating on the lines, the hydraulic generators running under constant load; it may act as a reserve in case of breakdown on line; and may serve to furnish the wattless current for the system, allowing other machines to carry greater overloads. The turbine unit may be run idle part of the year as a synchronous condenser, or may float on the line as such for part of the day and deliver energy at other times. Contracts for supply of continuous power, with severe penalty clauses, may necessitate the installation of an auxiliary plant at the distributing end of the line.

With improvements and reduction in cost and operating expenses of steam generating apparatus, the auxiliary plant becomes of increasing importance and, in some instances, threatens to become the more important. A form of water-power auxiliary was recently suggested in which the installed generator capacity far exceeds the normal flow of the stream. Water is stored throughout the day and the plant operated for but a few hours on peaks of systems.

A Floating Derrick.

The accompanying diagram shows a floating derrick recently built by the Wellman-Seaver-Morgan Co., which possesses the advantage over the stiff-leg derrick generally used of being able to swing through a complete circle. The crane itself is practically a standard 10-ton locomotive crane, and might be removed from the scow and placed on a truck to be used as such. In this particular case it was necessary to use a narrow scow, and a counterweight was accordingly placed below the boiler so as to keep the list within reasonable limits. The hatches of the scow were arranged so that the ballast can be handled by the crane itself; no ballast is required for light loads. The crane will operate at the following speeds: hoisting with full load, 50 ft. per minute; hoisting without load, 125 ft. per minute; rotation of crane with full load, 3 r.p.m., and without load 6 r.p.m.



A Floating Revolving Derrick.

Elephant Power is contemplated in the public works department of an Indian State, which has applied to "Engineering" for information on the proper rating for each animal. It is proposed to use them in working dynamos for six hours a day, storing the electricity in accumulators and employing it for lighting purposes at night. The inquirer wishes to know how many electrical units an elephant of ordinary strength working six hours will produce. Just what "gear" could be employed to utilize the strength of an elephant is a matter deserving study. A treadmill for such an animal would probably be more expensive than a small steam plant and not so reliable. If the animal were harnessed in a horizontal sweep its angular velocity in its circular path would defy the most skillful designer of slow-speed generators. A third suggestion, that the elephants might be trained to raise water in their trunks and squirt it on the blades of a Pelton wheel, borders so much on levity that it need not be discussed. As the problem is apparently a serious one to the Indian officials, it is submitted for the consideration of the inventive reader.

View of the Power Station and Coal Handling Equipment.

THE PENNSYLVANIA RAILROAD'S EXTENSION TO NEW YORK AND LONG ISLAND.

Some Details of the Long Island City Power Station.

Two companies have been incorporated through which the Pennsylvania R. R. Co. is carrying on its New York extension work. One of these, the Pennsylvania, New Jersey & New York R. R. Co. will build all of that portion of the tunnel and approaches in New Jersey to the boundary line of New York; from this boundary, the other, the Pennsylvania, New York & Long Island R. R. will construct the tunnels, terminal station and yards on Manhattan Island, under the East River and in Long Island City. The general features of the work were described in this journal on Oct. 10 and 17, 1903.

In the development of the large terminal system, which is to be entirely operated by electric power, two main generating stations were adopted, one in New Jersey and the other on Long Island. The latter station will also be the main source of power for the Long Island R. R. lines as fast as equipped, and the electrification of the Atlantic Ave. improvement, which was impending when the general project took shape, required the early construction of this station.

The great flexibility of the alternating current system of power transmission admits of placing the generating station at whatever reasonable distance from the natural center of load may be dictated by the important considerations of condensing water supply and cheap coal delivery, and the proximity of the East River was so obviously advantageous for both these purposes as to determine the selection of a situation abutting it. Such a site was available in Long Island City, convenient to the Long Island R. R. freight yard, enabling cheap handling of coal and ashes by rail, as well as the minimum expense for delivering building materials and equipment during construction. It is a 200x500-ft. rectangular block with the short side toward the river.

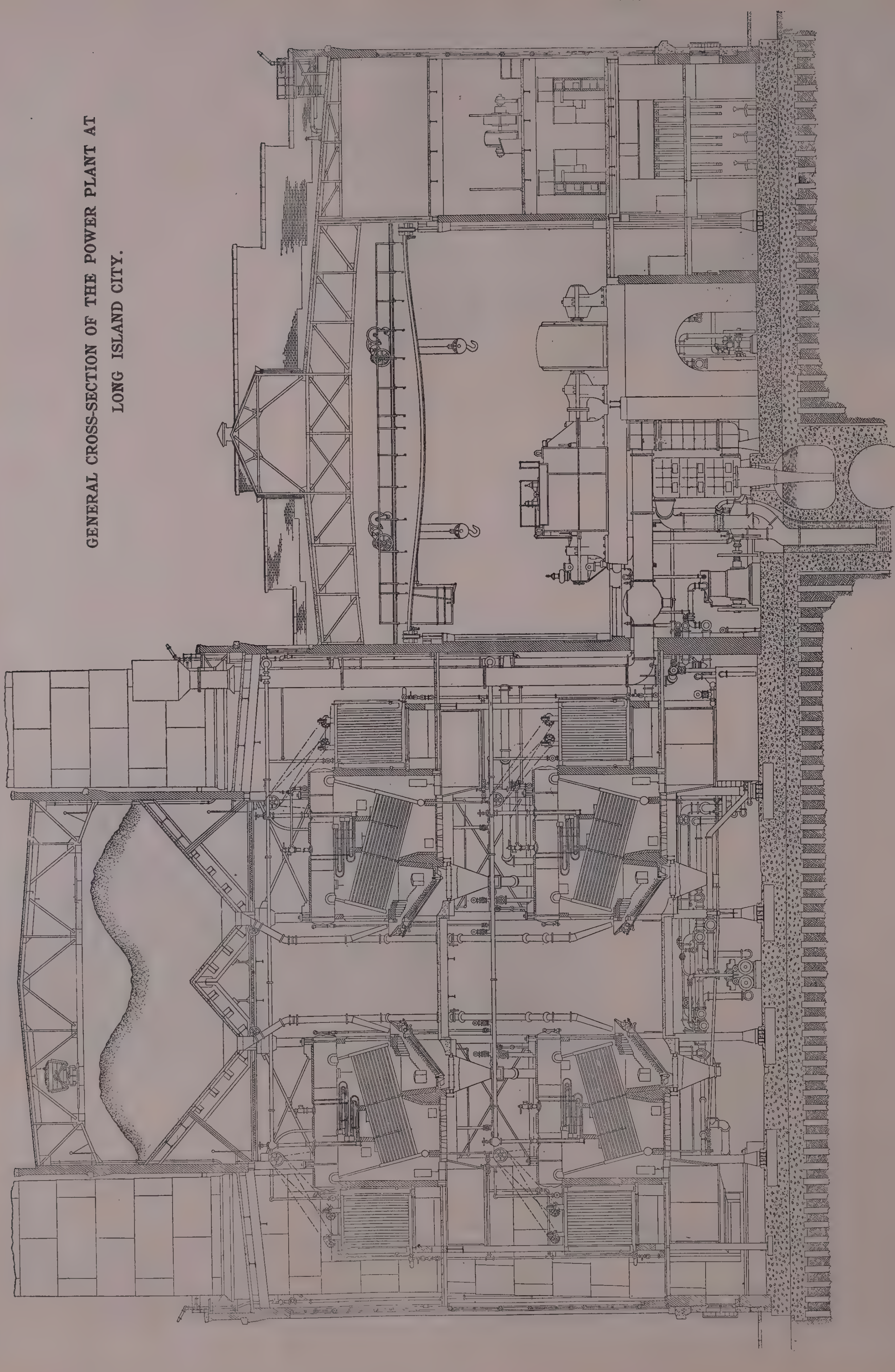
When the design was undertaken, the extent of electrification in sight required at least 50,000 kw. The largest steam turbo-generators then standardized were 5,500 kw., which became the unit basis of the station design. The plans will provide for fourteen such units in the building covering the block, or about 105,000 electrical horse-power, if such an amount of power be eventually required. For the initial load three 5,500-kw. units will suffice, and the building, as designed for this equipment, covers the full width of the block and half its length, and contains room for six 5,500-kw. units, and two 2,500-kw. units of the same type to be used for lighting the tunnels.

Foundations.—The soil at the station site consisted of from 10 to 15 ft. of loose fill and river mud overlying successive strata of clay, sand and gravel, with rock 35 to 60 ft. below the street level. A study of the monolithic and disconnected type of foundation showed the former was much less expensive. Individual piers would have necessitated a large amount of extra excavation, which, if utilized afterwards as a basement underneath the building would have had to be waterproofed and artificially drained. Tests indicated a safe carrying capacity for piles 30 to 35 ft. long of 13 to 20 tons. The foundation was designed to carry a load of 12 tons per pile, and the spacing averages 2 ft. 4 in. between centers over the entire area. The total number of piles required for the foundation was 9,115. The proper distribution of column loads down through the grillage beams and the concrete cap to the tops of the piles required the thickness of the cap to be 6 ft. 6 in., which permitted cutting off the piles 2 ft. 6 in. below high water level, in a water-bearing stratum of river mud. Underneath the stacks the concrete cap is 8 ft. 6 in. deep, the piles being cut off 2 ft. lower. The stack anchor bolts pass through a grillage of steel T rails, embedded in the bottom of the concrete. The concrete was mixed 1:2½:5, and used very wet; Dragon Portland cement was employed.

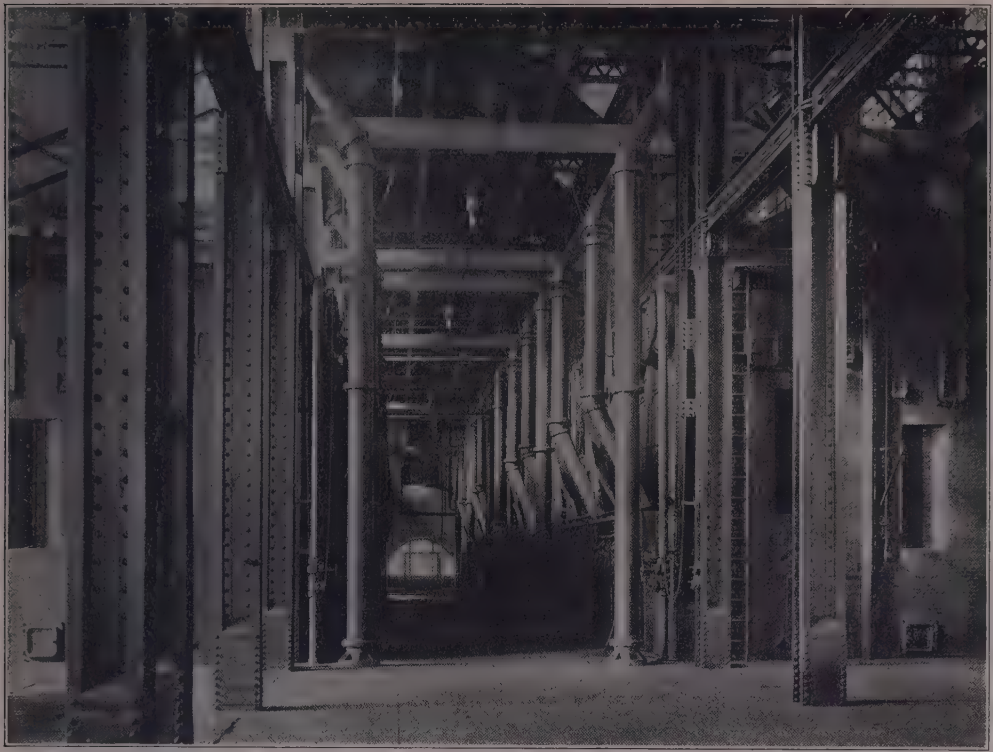
View of Power House during Construction, Showing Coal Bunker Framing.

The flume for the condenser intake, and the overflow flume directly above it, traverse the building foundations and are integral with it. Both are nominally 10 ft. in diameter, this large section being to provide sufficient condensing water with a low velocity of flow when the station is 500 ft. long and filled with generating machinery. The intake flume is always submerged. Fifty ft. from the bulkhead the tunnels separate, the overflow passing at an angle of approximately 45 deg. with the intake. The intersection of the overflow with the bulkhead is oblique in order to cause a long slow flow at the outlet. The spillway of the flume is formed as a dam, to insure a water seal on the discharge pipes of the condenser circulating system and to spread the warm water on the surface of the harbor to prevent its mixing with the condensing water entering through the intake. This design was adopted to save a few degrees of temperature of injection during the warm part of the year instead of suffering for the lack of it, as is the case in a good many plants in the vicinity. This separation of the outer ends of the flumes also enabled the racks and screen chambers of the intake to be made of ample size and readily accessible. The intake has an ice fender extending below extreme low water, to prevent a boat that may be lying against the face of the timber rack from packing ice against it and stopping the water supply. This rack extends from the bottom to the top of the intake opening, and is built of 3x10-in. yellow pine timbers spaced 4 in. apart in the clear. The face of the rack is inclined, so that floating objects drawn in by the current can be easily removed. Behind the rack is a screen chamber or well, with two sets of screens fitted in vertical cast-iron guides. Each set of screens is in three parts placed one above the other in the same groove, made up of oak frames and brass fittings, and on the front of the bottom rail of each section is a catch basket to retain falling objects when the screen is drawn up for cleaning or inspection. The outside screen is of iron wire, 1-in. mesh, and the inside screen is of No. 10 gauge copper wire, ½-in. mesh. A trolley beam and chain block are provided over the screen well to facilitate lifting out the screens and removing debris from the baskets. It was also decided to place a 30-in. connection from the overflow into the screen chamber so that under severest winter conditions, warm water might be run through on to the screen to prevent an accumulation of ice within the intake chambers.

Superstructure.—The over-all dimensions of



GENERAL CROSS-SECTION OF THE POWER PLANT AT LONG ISLAND CITY.



View in the Second Floor of the Boiler Room.

the present building are 200 ft. x 262 ft. outside measurement. The boiler house is 103 ft. wide inside, the engine room 66 ft., and the electrical galleries 25 ft. wide. The boiler-house proper is 82 ft. high to the top of the parapet. The coal pocket enclosure, superimposed on the boiler house, is 60 ft. wide, and its parapet is 118 ft. high. The engine room is 70 ft. high, to the top of the parapet.

The first floor of the boiler house is 16 ft. above the basement, and the second floor of the boiler room is 35 ft. above the first floor. In the engine house, the engine room floor is 23 ft. 6 in. above the basement, and thence to the roof trusses the height is about 40 ft. in the clear. This low head room is due to the use of horizontal steam turbines.

The steel framing of the boiler house and engine room are necessarily different in type, as the former has to carry a double tier of boilers with flues and economizers, with a coal pocket of 5,200 tons capacity on top of everything, while the engine room consists of simply a large open space which makes the roof truss construction the most conspicuous feature, but aside from this does not involve any difficult construction. The steel stacks are independent of the boiler house, except where they pass through the lower fire room floor, at which point the floor is built against them. The columns are grouped in the most effective manner to carry these heavy concentrated loads. Their bases are supported on grillages of steel beams embedded directly in the monolithic concrete foundations which underlie the entire structure. The general character of the steelwork is shown in the view of the power house in course of construction. It will be seen in this picture that a cross-section of the coal pocket closely resembles the letter W. This form was chosen on account of the location of the boilers in two rows separated by an alley, and the necessity of delivering the coal by gravity at points directly over the boiler fronts. Every portion of the bottom of the breaker has been designed to induce a constant movement of coal in the bins, thus tending to prevent fires.

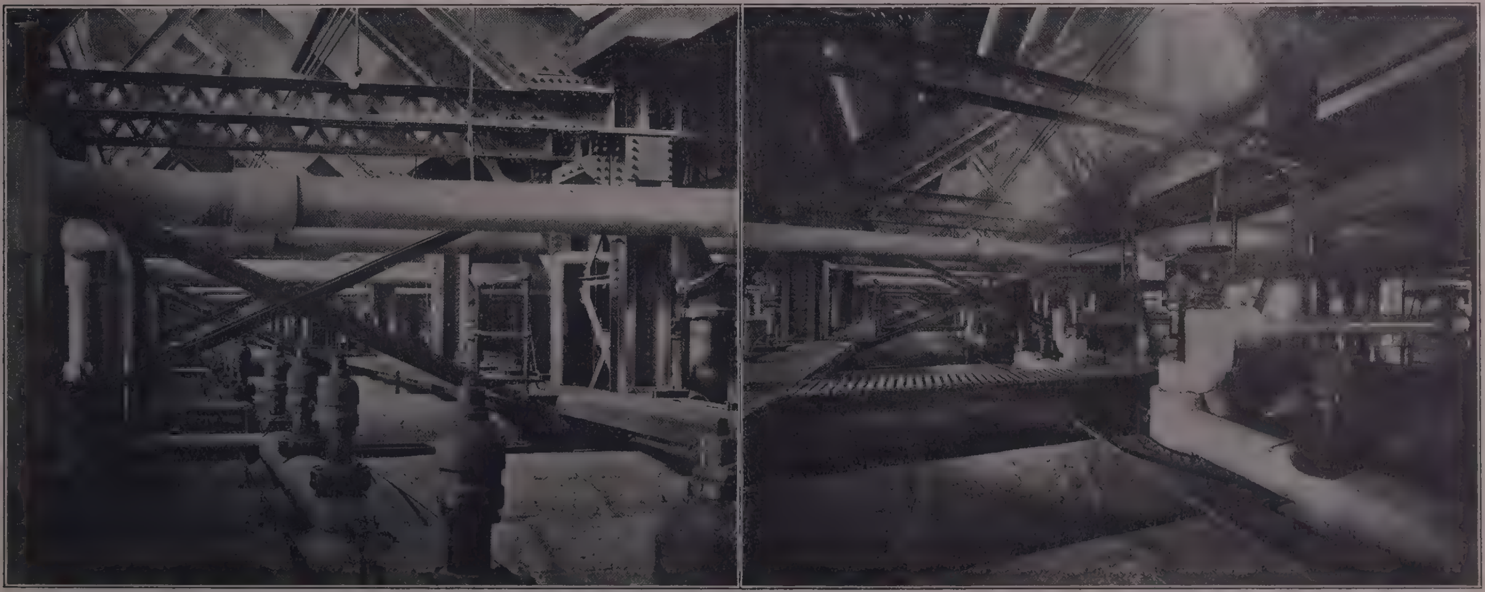
The character of the columns in the boiler house is shown in the illustration of the second-floor boiler room. The two views of the main steam piping over the boilers on this floor give an excellent idea of the construction of the underside of the coal bin, transferring its weight to the tops of the columns. Both views also show the unusually good lighting of the space between the top of the boilers and the bottom of the breakers. The details at the column bases are shown in the view of the condenser circulating and dry vacuum pumps. The roofs and floors are of concrete reinforced on the Ransome system.

Coal Handling Plant.—The plant was designed more particularly to deal with water coal, though certain provisions were made in the tower that will permit developing the station for handling coal from cars should it ever be desirable. The complete coal and ash handling plant, the coal hoisting tower, the cable railroad which carries the coal from the tower to the coal pocket and its supporting bridge, and the ash bin structure, are arranged to form a part of one of the piers of the cable railway bridge. This bridge is 107 ft. above the dock, and is at about two-thirds the entire height of the tower, whose top is 170 ft. above the dock.

The hoisting engine and apparatus is located within the four corner columns of the hoisting tower in an enclosure 25 ft. above the dock and having a height of 14 ft. The sides of this engine room are made of expanded metal and plaster, and the roof of cinder concrete, tar and gravel.

The upper third of the tower, extending above the level of the cable railway, carries the hoisting boom, the receiving hopper, coal crushing and weighing apparatus, and the cable railway machinery. The boom is 68 ft. long over all, and projects 43½ ft. beyond the face of the tower and over the slip 162 ft. above the dock. It consists of two parallel trusses thoroughly braced on top, and with portal braces at each panel point. It supports the trolley carriage from which the hoisting bucket is suspended, and over whose drums the hoisting cables operate. The track for this trolley is carried by brackets on the bottom chord of the boom.

For about 34 ft. above the level of the cable railway, the upper third of the hoisting tower is completely enclosed with corrugated copper sheathing, forming a house with two stories. The lower house contains the weighing mechanism, and the engines driving the crushing machinery and the cable railway, and the upper



Main Steam Piping over Boilers on Second Floor and Framing of Coal Bunker Floors.

story containing the crusher. The roof of the crusher room is formed by the receiving hopper.

Between the coal tower proper and the boiler house structure, a distance of about 500 ft., there are four bridge spans supporting the cable railway. The two outermost spans of this bridge are 140 ft. 6 in. in length, the third about 149 ft., and the span from the ash tower to the boiler house is 70 ft. The combination of the high level cable railway bridge and the hoisting tower of corresponding height, enables all the hoisting to be done at one operation, without the pulverizing of the fuel incident to passage through a succession of conveyors or elevator devices.

The tower is of the "one man" type, and has a capacity for 400 long tons of run-of-mine bituminous coal in five working hours. The mechanism controlling the operation of the bucket is only a short distance above the barge being loaded so that the operator can run the plant during foggy weather, which makes it necessary to shut down when the operator is aloft. Another new element in the design is a third hoisting engine for opening and closing the bucket, in addition to the two engines ordinarily used, one for hoisting it, and the other for trolleying it along the boom.

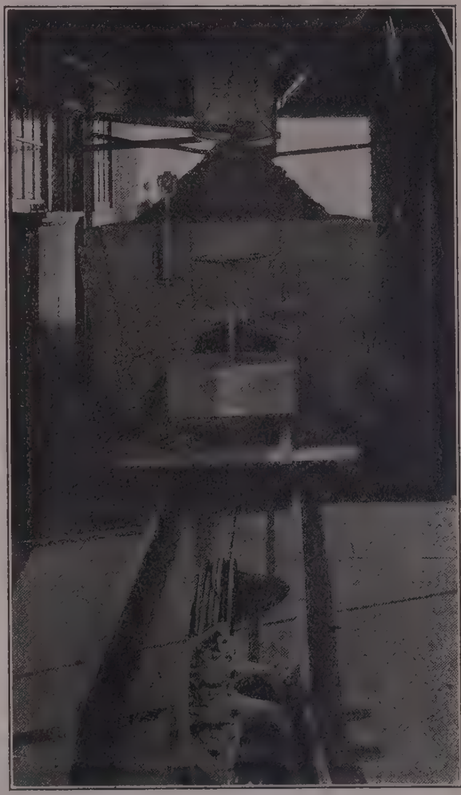
The apparatus consists of heavy steam hoisting engines of standard type, with an arrangement of ropes, sheaves, and counterweights similar to that in satisfactory use for years past in the best steam elevator practice. The trolley is balanced so that it is not necessary to operate the hoisting engines when trolleying, and the clearance between bucket and boom is maintained constant, while the application of counterweights to the bucket hoist enables the omission of friction brakes which have proved troublesome in high towers. A system of stops automatically prevents overhauling on the hoisting apparatus.

The coal is hoisted in a two-ton Haywood clamshell bucket by a two-cylinder 15x24-in. Lidgerwood engine. The bucket is so counterweighted that when lowered its speed cannot exceed 1,000 ft. per minute. It is suspended from a substantial trolley carried on a rigid boom built of steel trusses in parabolic form, and projecting 43½ ft. beyond the tower at a height of about 163 ft. above the dock. The opening and closing of the bucket is done by an 8x10-in. Lidgerwood "biter" engine, which can also be used to drive the winch head for warping barges along the dock, at which time it is disconnected from the biter mechanism. The trolley motion for running the bucket in or out along the boom is operated by a 6x8-in. Lidgerwood engine. All engines work at 160 lb. steam pressure supplied from the main boiler house and are located in the engine room in the base of the tower.

The bucket is lowered into the barge with the jaws open, and the sharp edges of the bucket naturally dig into the coal to a sufficient depth to allow the enclosure of a full load of it as soon as the jaws are closed. The closing of the bucket is done by the biter engine which operates through a series of steel ropes working around the sheaves and brings the jaws of the bucket together without lifting it out of the barge. When the bucket is closed the hoisting engine starts automatically a continuous hoisting until the bucket reaches its predetermined maximum height, about 150 ft. in the air, the maximum rate of hoist being about 1,400 ft. per minute. At this point the hoisting ceases, and the trolley motion starts automatically, running the bucket in on the boom until it is over the receiving hopper and then automatically starting the biter mechanism in the reverse direction and dumping the load by opening the jaws of the bucket. The return movement of the bucket is controlled by the operator. The mechanism is equipped with a full set of limiting and safety devices as well as indicators for the guidance of the operator. The bucket can complete a round trip, i.e., load, hoist, trolley in over the hopper, dump, trolley out, and descend again to the barge in 45 seconds. The machinery for hoisting and trolleying the operation of the bucket was designed and built by the Robins Conveying Belt Co.

The receiving hopper is built of steel plate, and the coal passes through it by gravity to the shaking bottom, which allows certain small bituminous or small anthracite coal to pass around the crusher to the loading hopper and delivers the large coal to the crusher. The shaking grate and the crusher are operated by the same engine, which is a 7½x7-in. Westinghouse Standard engine.

The crusher has a capacity of 400 tons in five hours, and the coal after passing through it drops directly into the loading hoppers, which are directly above the scale platform. They are equipped with gates operated by the weigher who loads the cable cars as they stand upon the platform. The scales have a capacity of five tons. A car receiving its load of coal on the weighing stand is shown in an accompanying illustration.



Loading Platform in Coal Tower.

The cable railway itself is designed for a capacity in excess of the other portions of the mechanism above described. That is, it is capable of handling 150 tons per hour, when operating twenty-nine 2-ton cars at a speed of 180 ft. per minute around a track loop approximately 2,500 ft. long. There are at present installed ten cars, each of about 2 tons capacity. The cable is ¾ inch, six strand, extra crucible steel wire rope, laid on hemp centers. It is driven by 7½x7-in. Westinghouse Standard engine, and is kept taut by a heavy counterweight. The engine driving the cable is under manual control, and together with the crusher engine are in a little engine room on the same level and adjacent to the scales so that the entire mechanical outfit of this part of the plant is under the control of one man. The cable railway engines, however, can be shut down automatically if the cars are not properly released from the cable at the right point just before reaching the loading platform on the return journey where the cable leaves the roadway in order to come over the winding drum. At this point there is situated an automatic tripping device for releasing the grips, so that they do not require attention when they arrive empty from the coal pocket.

The coal cars are of the side dump type, the sides being designed to swing outward and the bottom being inclined outward so that the coal when released by the swinging out of the sides, drops out of the car. The tripping device consists of a heavy cam bolted to an I-beam running directly over the center of the track. The cam engages an arm that projects upward from the car causing it to actuate the dumping mechanism on the car, thus dispensing with the necessity of any labor at the coal pocket, except the occasional relocation of the cam. The car dumps its load without letting go of the cable, proceeds around the loop and returns to the loading hopper automatically.

It is estimated that the actual cost including labor, supplies, and fixed charges per ton of coal from the time it leaves the barge until it arrives in the bin, on the basis of 480 tons per day, is 9 1/3 cents per ton.

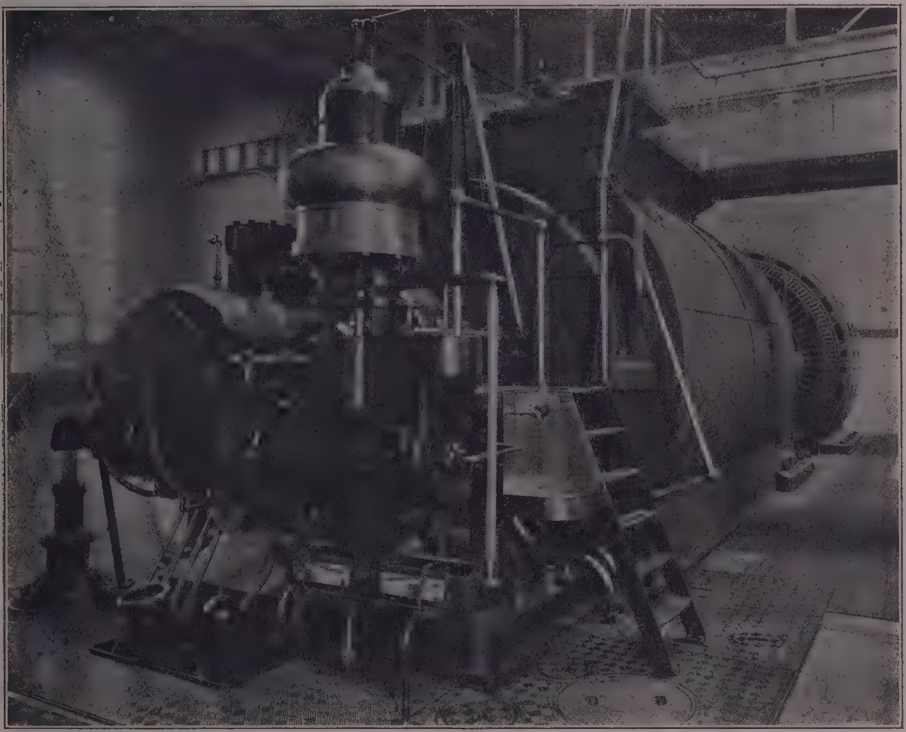
The ash bin is under the cable railway and separated from the boiler room by a narrow street. Ashes are delivered to it through a bridge 69 ft. above the street by a telpherage system which hoists and transports the ash cars from the boiler room basement to the level of this bridge and thence over into the tower, where the contents are dumped into the bin. The bottom of the bin is 20 ft. above a railroad track that runs through the base of the tower, and the ashes are handled through dumping gates into gondola cars standing on this track. The capacity of the bin untrimmed is 300 tons.

Ashes are dumped through hoppers in the bottom of the stoker pits into small cars having the body detachable from the truck. The loaded car is run along a narrow gauge railway in the basement floor underneath the line of dumping hoppers to a turntable at the west end of the boiler house basement directly under the end of the ash bridge. A trolley hoist is provided which runs on a 10-in. I-beam from a point over the ash bin through the bridge and over the turntable. From the trolley carriage are suspended by means of wire cables two sheaves with hooks to be inserted in the rings at each end of the car body as it stands on the turntable in the basement. The cables are then wound up on the grooved winding drums of the trolley hoist, raising the bucket to the proper height opposite the ash bridge, at which point by the action of an automatic switch the operation of the hoisting is stopped, the trolley motion is started and then the bucket is carried to a point over the ash bin, automatically dumped, reversed, returned again to the inner end of the trolley hoist and finally lowered to the turntable in the boiler house basement. The entire cycle of operations is effected by hand control of a single starting switch, the control of trolleying, dumping and lowering being entirely automatic, the attendant simply closing the pilot switch.

The trolley is capable of hoisting one ton of ashes in a bucket weighing about 1,500 lb., at a speed of 60 ft. per minute, the speed of trolleying back and forth through the bridge being 250 ft. per minute. The distance of hoisting and lowering is 70 ft. each way, and the horizontal distance traveled by the trolley is 100 ft. in each direction. The time required for a round trip of the bucket between the power house basement and the ash bin is about 3½ minutes.

Water Supply System.—Water is taken from two mains of the Montauk Water Co., connected to an 18-in. pipe supplying the power house.

To be sure of having a reserve on this supply, there was built adjacent to the Long Island R. R. yard, at a distance of about 2,700 ft. from the station, a standpipe 40 ft. in diameter and 80 ft. high, connected into this 18-in. main and under ordinary circumstances kept full. From the 18-in. main two 14-in. branches are carried into the building, each having two 10-in. meters in multiple with suitable by-pass connections. A third water connection of the same size is provided from the same main at the southeast corner of the power station. There are also two independent cross connections between this 18-in. supply line and the city water system, for use in case of accident to the Water Company's pipe line. The two 14-in. branches are joined inside of the building forming a loop, which in case of emergency can supply directly the suction for the feed pumps, although under normal conditions this water is only used as needed for make-up, added to the water of condensation returned from the surface condensers.



Steam End of 5,500-Kilowatt Turbo-Generator.

Owing to the use of surface condensers the major part of the boiler supply is derived from the hot wells receiving the discharge from the surface condensers. For each generator unit two hot wells are provided in the form of steel tanks 18 ft. 4 in. by 18 ft. 5 in., and 6 ft. 6 in. deep, to which the water of condensation is pumped. Although each unit has its own pair of hot wells, they may all be connected together. The water in these tanks is kept at a constant level by the addition of the "make-up" water, added automatically through a pump governor actuated by a float valve in the tank. The make-up water is taken from the outside supply mains, and the pipe connections are so arranged that it may first be used, if desired, for cooling purposes around the building, such as in jacketed bearings, whence it passes to the open heater. Otherwise, it goes directly from the mains to an open Cochrane heater, 8 ft. in diameter and 15 ft. long, which utilizes exhaust steam from the double-acting auxiliary engines and reciprocating pumps in various parts of the building. It has sufficient capacity to heat feed water for 15,000 h.-p. of boilers from 40° to 205° F.

It was made purposely large in order to insure a comparatively slow circulation of the make-up water through it, so that it would have ample time to throw off the carbon dioxide and other injurious substances in solution which would attack the valve seats and the tubes in economizers and condensers. The make-up water is likely to run from 10 to 15 per cent. of the entire water consumption of the plant. The heater is really more of a purifier than a heater. The arrangement was designed with this particular object in view. The Westinghouse single acting engines driving auxiliary machinery do not send their exhaust steam to this heater on account of the particles of crank case oil that may work into the exhaust, but the ordinary cylinder oil in the exhaust of the pumps and double-acting engines is extracted by allowing the steam to run at a very low velocity through a comparatively large pipe before reaching the heater, and thence into a 26-in. Cochrane oil separator, by which means it is effectually extracted.

By the course of treatment above outlined, the purity of the water in the steam in all parts of the system is insured, resulting in a marked decrease in corrosion and leakage in all parts of the plant with a corresponding reduction in operating expense and depreciation. For instance, the wear and tear on both water and vacuum pumps is appreciably reduced by reason of the lower speed made possible by the absence of leakage.

Boilers.—There are 32 Babcock & Wilcox boilers set in batteries of two each, eight batteries on the first floor and eight on the second floor immediately over the former; these batteries are equally distributed on each side of the boiler plant, with a firing space between boiler fronts of about 18 ft. in width. Ultimately 96 boilers will be installed.

The boilers are designed for a working pressure of 200 lb. and each has a total effective water heating surface of 5,243 sq. ft., comprised in steam drums 42 in. in diameter and 23 ft. 10⅝ in. long, and twenty-one sections of 4-in. tubes 18 ft. long, with twelve tubes in each section. Each boiler is supplied with a B. & W. superheater, capable of raising the output of the boiler 200° Fahr. when operating at 200 lb. pressure. Each boiler has two steam openings, the main nozzle receiving steam from the superheater, and the auxiliary nozzle taking its saturated steam directly out of the tops of the boiler drums for use in the mains supplying the small engines in various parts of the house.

Each boiler is fitted with a Roney stoker 150 in. wide. It has twenty-four grate bars, with a dumping grate at the bottom to drop the ashes into the ash pit. The bars are rocked by a small Westinghouse engine, there being one engine to eight stokers. An arrangement is also provided for blowing in steam above the grates in order to disintegrate clinkers if necessary. The contents of the ash pit are discharged down a chute terminating over the narrow gauge ash railway in the basement, already described.

Flues, Economizers and Stacks.—The arrangement of flues, economizers and dampers permits the operation of the plant by working each set of eight boilers on one turbine, but the flues and economizers can be cross connected to insure the greatest capacity and highest efficiency under all conditions of operation, even though some portions of the boiler and economizer plant may be out of service. One economizer utilizes the waste heat from two batteries of boilers.

Under normal conditions the gases from the four boilers discharge into their respective sections of the main flue, then pass through the economizer directly above, and into the stack, but dampers on the first and second floor permit inequalities of quantity and pressure to divide under the different economizers irrespective of the boilers in service. In case it is found necessary to isolate any economizer for cleaning and repairs, the gases can be by-passed directly into the stack or divided up through the other economizers. The second floor boilers can discharge into the stack through the flues and economizers and the first floor or vice versa. All the boilers can discharge through one economizer, or all economizers can be cut out, and stacks may also be cut out.

Each economizer consists of fifty-six sections of ten tubes each, designed for 250 lb. pressure. The rear wall of the economizer chamber is made of vitrified asbestos air cell board, laid on in sections, so that if an economizer tube breaks it is not necessary to tear down any of the brickwork in order to replace the section. By the use of these economizers the hot gases are so reduced in temperature that they enter the base of the stack at about 350°.

There are four stacks in the station, of which only two are required for the operation of the present installed apparatus, but it was deemed advantageous to erect all four. When the station is extended, the number will ultimately be six. They are of steel, are entirely self-supporting and are 275 ft. in height above the base. The inside diameter of the straight portion is 17 ft. 10 in. at the bottom and 16 ft. at the top. The bottom courses are flared out to a diameter of 23 ft. They are lined throughout with brick, which is supported at intervals of 20 ft. with Z bar rings riveted around the interior of the stack. Each stack has six openings, two in the basement for the main flues, two for the boiler flues on the first floor and two for those on the second floor. These openings are all heavily reinforced with plates and angles. The concrete base of the stack is formed solid with the monolithic building foundation, and is run up 3 ft. above the basement floor, which gives an average height of 245 ft. above the furnaces. The plates composing the stack are of open hearth steel, varying by sixteenths from ½ at the bottom to 5/16th in. at the top, the rivets being ⅞ and ¾-in. Each ring is a cylinder, the lower plates being outside of the upper, so that the stack naturally tapers towards the top.

All the upper edges of the plates were beveled to admit of caulking so as to prevent rain working into the joints and deteriorating the inside of the plates. The space between the plates and the brick lining was grouted full of cement mortar in order to further protect them. The plates employed were larger than usual to reduce the number of joints. Above the second opening, no ring is composed of more than four plates, the largest of which are about 6½x15 ft. The stack is fastened to its base by a segmental cast-iron ring 23 ft. in diameter, held down by twenty 3-in. anchor bolts, which pass through a grillage in the bottom of the concrete foundation. On the top is a cast-iron astragal made in eight segments with a Z-bar painting ring. Just above the boiler house roof is a rain shield to cover the opening. In the interior of the stack are two dampers set in diaphragms for the proper diversion of the flue gases.

Steam Turbines.—The three main turbines are of the Westinghouse-Parsons single-flow type, rated to develop 5,500 kw. at 175 lb. steam pressure, and 27½ in. vacuum, running at 750 r.p.m. This type is too well known to need detailed description, but attention is called to the accompanying view of the steam end of a turbo-generator, showing the system of levers fulcrumed upon the governor spindle and actuating the main admission valve on top of the turbine casing. Directly under the governor there is suspended a rocker carrying a weight which can be moved along it from one end to the other by a screw forming the extended shaft of a little motor carried on the rocker. This rocker is continually oscillating, receiving its motion through a vertical rod attached to the outer end of the governor lever system. The inertia of the governor leverage system is altered and its amplitude of vibration consequently changed, by changing the position of the weight on the rocker, through the operation of the little motor, which can be seen at the left-hand end of the rocker. This motor is controlled by suitable switch gear located in the electrical operating gallery, so that the switchboard attendant whose duty it is to throw the machines in parallel, has simply to manipulate this speed changing device, in order to attain synchronism with the generator which he is about to couple to the system.

The turbine is also fitted with an automatic safety stop arrangement which shuts off the steam supply automatically in case the speed exceeds the predetermined limit. A device is also provided for controlling the action of the relief valve in the outboard exhaust connection.

Convenient to each turbine there is a bracket on the boiler room wall carrying a stop valve by which steam supply to each turbine unit can be cut off in the boiler room without leaving the engine room floor.

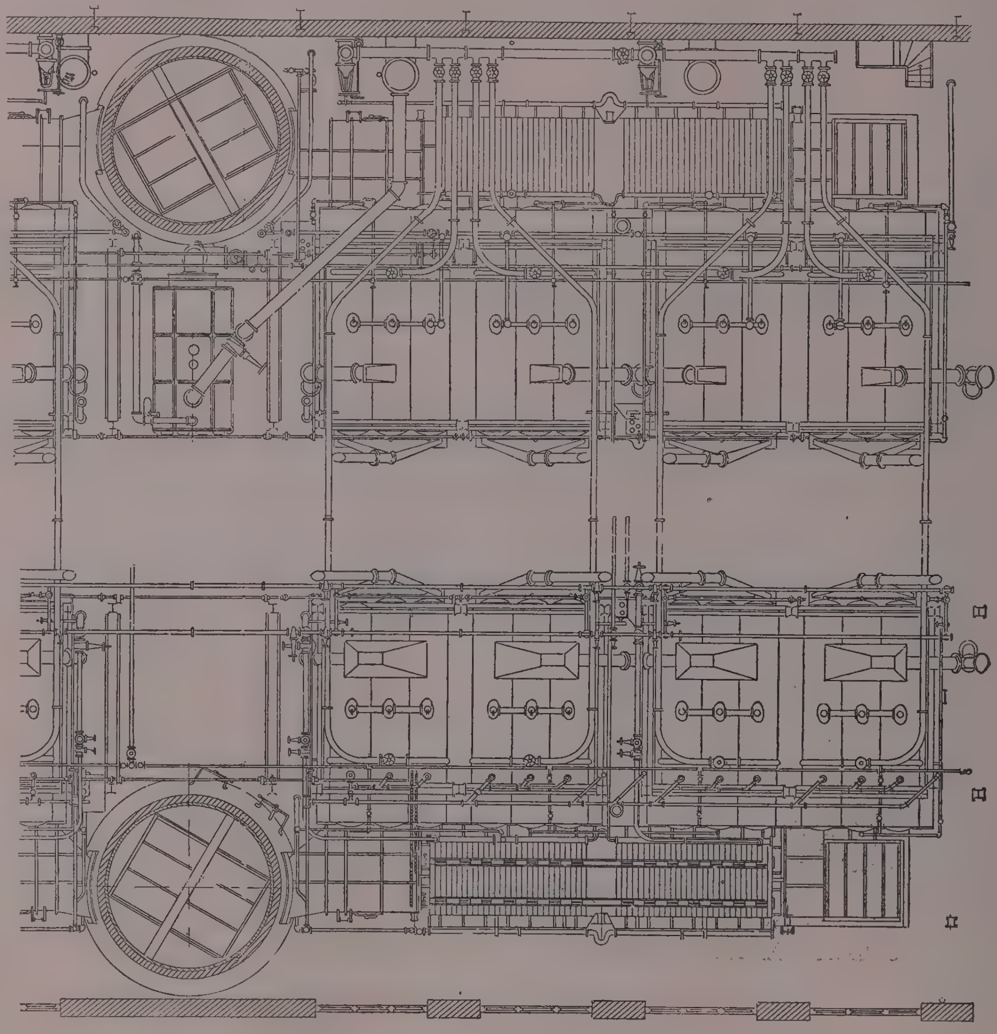
Condensers.—A separate condenser is provided for each turbine, of the counter-current surface type, built by the Alberger Condenser Co., and having 20,000 sq. ft. of cooling surface. The condenser is placed in a large arched opening made in the turbine foundation.

The exhaust trunk is of cast iron, rectangular in section, well ribbed up on the outside. The outboard exhaust passes over the top of the condenser, through a 36-in. relief valve, to an independent vertical 36-in. exhaust pipe passing up through the roof behind the boilers.

The exhaust steam enters the condenser at the bottom. The dry air pump exhausts the vapor from the top and the water of condensation is collected from the bottom by the hot well pump. The circulating water enters the tubes at the top, makes three passes, and is discharged from the bottom of the condenser into the overflow flume directly underneath.

The intake flume is underneath the overflow, and access to its contents is made possible by a well extending past the outflow flume down to the intake flume. Condensing water is lifted from this well by a 24-in. double suction centrifugal pump made by the Morris Machine Works, capable of pumping 20,000 gal. of salt water per minute against a head of 20 ft. Each pump is driven by a 12x24x12-in. Westinghouse compound engine direct connected to it.

The condensed steam is drawn from the bottom of each condenser and discharged to the hot well tanks in the boiler room basement, by a 4-in. centrifugal pump direct connected to a 15-h.p., 220-volt, direct-current motor running at 560 r.p.m. A by-pass arrangement to the overflow flume is provided for discharging the condensed steam directly into the flume if desired.



Partial Plan of Boiler Room Arrangements.

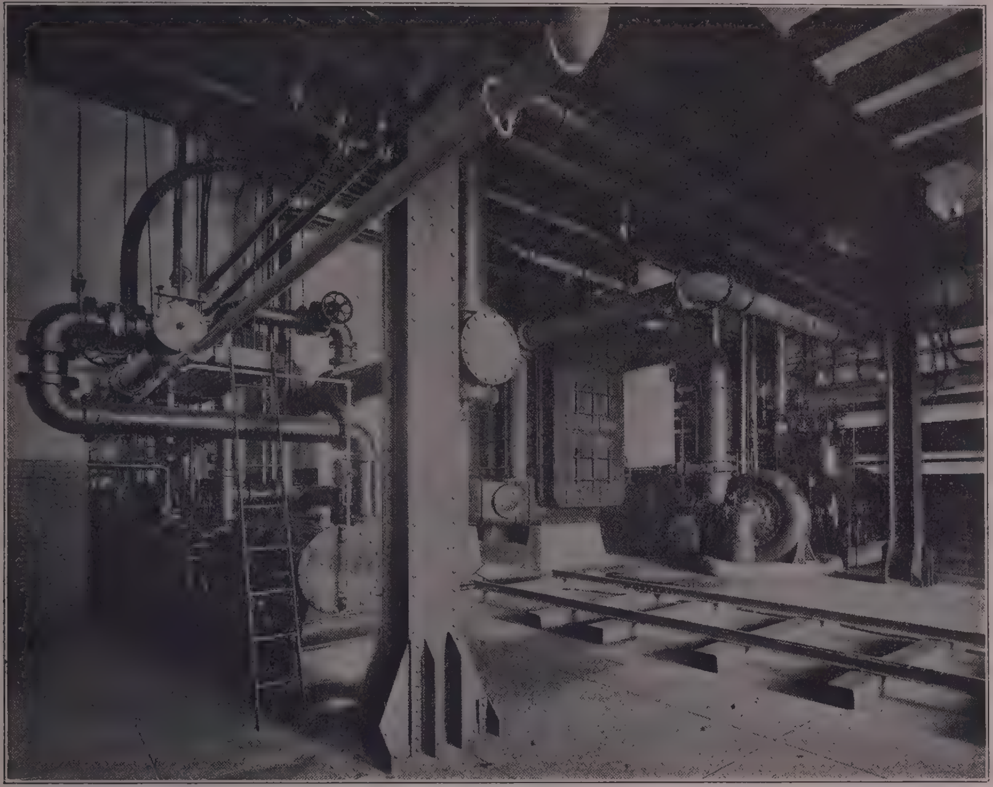
The relation of the hot well tanks to the boiler feeding system, has already been outlined.

Vacuum is maintained in each surface condenser by a horizontal steam-driven, two-stage dry vacuum pump, with Corliss valves and automatic governor on the steam end, and positive valve motion on the vacuum end. The vacuum cylinders and heads are water jacketed. The steam cylinders are 10 and 24 in. in diameter, and the pump cylinders 24 in. in diameter, with a 24-in. stroke, and its normal speed is 100 r.p.m. They are built by the Alberger Condenser Co. An accompanying illustration shows the centrifugal circulating pump, and its engine, and also of the dry air pump, which, like the condenser, is placed in an arched opening in the engine foundation.

A somewhat unusual feature has been introduced into this station to prevent the serious deterioration usually occurring where salt water is used for circulation of surface condensers. It is the universal experience that more or less galvanic action takes place in any event at the expense of condenser tubes, but this is often aggravated in large and important plants by the fact that the water and the body of the condenser have formed a convenient path for stray electric railway return currents getting back to their own power station some distance away, through the condenser intake and the water of the harbor. A sufficient number of voltmeter readings were taken between the river, the flume, and various parts of the piping about the building and in the streets, to indicate that there was at all times difference of potential enough to make trouble, although its polarity was not always the same.

The method adopted to prevent this corrosion consists first in providing a shunt circuit between the incoming water pipes and the condenser flume, in order to divert as large a proportion as possible of the current from the condensers. This was done by the insertion in each water main connection of a short piece of pipe with an insulating joint on each end of it. These short pieces of pipe were then connected to a 750,000 C. M. cable which was carried to the outer end of the condenser intake. Such current as may leak from the pipes to the water contained in them thus has an opportunity to get back into the harbor without going through the piping system and the condensers.

In order to neutralize the effect of such current as might still leak past the insulating joints, a small booster generator was provided driven by a 220-volt motor, the positive pole of the booster being connected to the heavy grounded shunt cable above mentioned, the negative pole being connected to seven different points on each condenser, there being an adjustable rheostat in each of these branches of the negative circuit. This superimposed voltage can be adjusted by means of the rheostats to counterbalance exactly the natural galvanic electromotive forces due to the brass tubes, the iron shell and the circulating water, together with the stray electromotive forces from outside. With the destructive potentials so counterbalanced, the condenser is in a neutral electric state, which effectively prevents the corrosion and pitting of condenser tubes and sheets and secures a far longer life than has hitherto been possible for this highly vulnerable section of the steam equipment. A little switchboard panel is provided for each condenser, with seven rheostats mounted on it, each of which is connected by a separate negative lead to a different section of each of the three condensers.



Condenser Circulating and Dry Vacuum Pumps.

A differential voltmeter is provided which can be plugged to each of these sections of the negative circuit, there being a separate rheostat in each circuit. By adjusting the rheostats for each section it is possible to keep the potential at zero in all of them. The booster apparatus is conveniently situated in the electrical bus gallery directly under the operating gallery. The rheostat panel for each condenser is situated conveniently to it in the engine room basement, and observations at suitable intervals enable the operating force to maintain the condensers absolutely neutral.

Steam Piping.—In general, the piping for the main power units in the plant was laid out to conform with the general design of the station on lines of the unit system above referred to. In other words, the piping was so arranged that under normal conditions a given group of boilers and auxiliaries serves a single main power unit, which is provided with suitable cross and equalizing connections between itself and the similar system of piping of the adjacent power units.

The general arrangement of the main steam piping is such that four boilers on each floor or eight altogether, feed directly to a separate main generating unit, with a cross connection header located back of the first floor boilers, joining these separate feeders, and fitted with suitable stop valves.

An accompanying illustration gives a view of the manifold connection where the group of boilers on the second floor discharges its steam into the top of one of these main feeders, which is then carried down to the point where it passes through the engine room wall under the turbine operating floor, having on the way a connection from a similar manifold with the corresponding group of boilers on the first floor.

Manifold Connection in Main Steam Piping.

The two boilers on the south side of the boiler room are run into the same manifold as the two boilers directly opposite them on the north side, and the same arrangement is carried out on the lower tier of boilers. The left-hand picture of the two showing the piping over the boilers on the second floor indicates how these boiler branch connections originate. The right-hand picture of the same pair shows how these main steam pipes run across the boiler house. These three views show quite clearly the character of the main steam connections. It will be noted that they do not take steam directly from the boiler drums, but are brought up directly from the superheaters. The connections shown coming directly from the tops of the boiler drums are those feeding the auxiliary steam main.

As it is planned to use steam up to 200 lb. pressure, with 200° superheat, special care had to be taken to allow ample flexibility. Long radius pipe bends were used throughout and this arrangement has been found to furnish ample flexibility under the most exacting conditions. Full weight steam pipe with extra heavy welded steel flanges was used throughout on the main steam piping. Open-hearth cast-steel fittings were used. Particular attention is called to the heavy manifold connections, where four 7-inch boiler connections enter one 12-in. main.

The valves used on this section of the work were specially designed for service under these exacting temperature tests. They are constructed of semi-steel throughout, with integral seats and specially designed stuffing boxes. Gate valves were used throughout except at the boiler nozzles where automatic reverse current stop and check valves were provided.

The joints were made up with particular care, steel bolts and corrugated copper gaskets being used throughout. The faces of the flanges on the piping, valves and fittings were raised inside of the bolt holes, and the raised faces given a smooth machine finish.

The heavy manifolds above mentioned are supported on springs from steel frame platforms that are suspended from the roof beams, the springs being introduced to insure support from the pipe when it expands upward, these large risers being supported from the bottom.

The auxiliary piping supplies the steam for the reciprocating steam driven auxiliaries, including the boiler feed pumps, circulating and dry air pumps, stoker engines, together with all reciprocating pumps on the various water and oil systems above mentioned distributed throughout the station. These connections are provided only with the boilers on the engine room side of the boiler house. There is an auxiliary steam line in the basement of the engine room and another in the boiler house basement, and these are so cross connected as to form a loop in much the same way as in the case of the boiler feed piping. Automatic reverse current boiler stop and check valves are also provided on boiler connections of the system, all other valves being of the gate pattern. The lines are constructed with heavy weight piping with extra heavy cast-iron fittings and flanges, and the joints were made with corrugated copper gaskets, and the loop is subdivided into sections by valves so that any section may be cut out without shutting steam off the others.

The main outboard exhaust connection for each turbine leading above the roof of the building, is 36 in. in diameter. This becomes operative through a horizontal relief valve hydraulically operated, the dash pot and operating gear being worked from the engine room floor. The upper end of the atmospheric exhaust pipe is fitted with a Stein exhaust header. In connection between the turbine and condenser is a copper expansion joint to prevent strains due to expansion and contraction. There are no cross connections between units, in the main exhaust piping system.

There are three systems of distribution of lubricating oil. First is one which distributes oil to the turbine bearings and includes a storage tank 8 ft. in diameter by 14 ft. 8 in. deep, situated in the boiler house at about the level of the coal bunker from which oil is distributed by gravity to the turbine bearings. From the bearings it is carried to a filter tank from which it is pumped automatically to the storage tank again. The filtering plant is located in a two-story closed chamber, the upper story containing several tiers of filter pans which carry the bags through which the oil runs, the lower story containing the tank and pipe discharge connections to the oil pumps which are situated on top of the structure. There are about 5,000 gal. of oil in this system and about 90 gal. per minute is circulated through each turbine when in operation. About 20 gal. per day is drawn off for various purposes, and there is a very small loss by evaporation.

The oiling system for the crank-cases of the Westinghouse engines used for the auxiliaries includes a storage tank 3 ft. in diameter by 10 ft. 9 in. high, which supplies by gravity a system of piping that leads to all Westinghouse reciprocating engines and allows the addition of new oil when needed. The discharge from the engine crank-cases is pumped to a filter tank and thence flows to a drain tank, from which it is pumped through a system of piping leading back to the engines.

Cylinder oil for the lubrication of the cylinders of the reciprocating engines is handled by the system which includes a storage tank feeding by gravity through a system of piping that serves the lubricators on all the reciprocating engines and pumps. Fresh oil is raised into this storage tank from small receiving tanks by means of compressed air.

Except in the crank case oil return line, which is of standard weight wrought-iron pipe, all oil piping is of brass, with cast-iron fittings. All sizes above 4 in. are fitted with cast-iron flanges into which the brass pipe is expanded.

Compressed Air Cleaning System.—The station is equipped with a compressed air system for cleaning and other purposes. Air is supplied to this system by two water-cooled, motor-driven compressors of the Westinghouse Traction Brake Co.'s type. Each has a capacity of 50 cu. ft. of free air per minute, at 100 lb. pressure, and is controlled automatically by a pump governor. The compressed air is used for cleaning the main and auxiliary generators, switchboard apparatus, and electrical accessories, and also in connection with the oiling system for forcing new cylinder oil and new crank case oil into the storage tanks from which these oils are delivered to the oiling system. It is also used for an air hoist for handling oil barrels and emptying them into the receiving tanks. The pressure usually carried on the system is 80 lb. The system is made up of standard wrought-iron pipe with extra heavy fittings and valves.

Pipe Covering.—The non-conducting covering applied to the pipes and other heated surfaces throughout the building was furnished and put on by Keasbey & Mattison. That on the superheated pipes consists of a 1-in. layer of asbestos cement and then a 1-in. layer of 85 per cent. magnesia blocks covered again with ¾ in. of cement enclosed in a heavy canvas jacket. The saturated steam pipes are covered with 1½ in. of 85 per cent. magnesia jacketed with heavy canvas. Boiler feed lines and high pressure drips and all other auxiliary piping and heaters are also covered with 85 per cent. magnesia in varying thicknesses. The smoke flues are jacketed first by a 1-in. air space and then with 1 in. of 40 per cent. magnesia overlaid with a ½-in. coat of hard finishing asbestos cement. These non-conducting coverings are held by galvanized iron netting and tie wires underneath the canvas.

The covering of the flanges and fittings on the superheated steam lines was of the special sectional design so as to be readily removable. Canvas covering on pipes and other surfaces was given two coats of paint, and a general color scheme was devised for the purpose of indicating at a glance the various systems of piping. The scheme was very carefully worked out, and has been found of great convenience to the operating force. It is as follows: White, high pressure steam lines. Bright red, drips from superheated steam lines, including Holly system and connection to boilers. Bright red with black flanges, saturated steam lines and Holly system connections. Yellow, exhaust from auxiliary apparatus and low pressure drip pipe. Black, boiler feed piping, from feed pumps to boiler drums including heaters, economizers, and their connections. Blue, all water piping except the feed pipes, between water pumps and boilers, and excepting fire lines. Structural color, fire protection system, this being painted to match the structure to which it was adjacent. Maroon, blow-off piping. Green, air pipe. Slate, crank case oil piping between engines and separators. Brass, not painted, all oil piping, except the above-mentioned oil pipes painted slate color.

All the gate valves are made by the Chapman Valve Mfg. Co., and the globe valves by the Star Brass Co.

Electrical.—The turbo-generators are each guaranteed to deliver 289 amperes per terminal at 11,000 volts, and 80 to 100 per cent. power factor for a space of 24 hours continuously, with a rise in temperature not to exceed 35° C.; and a 50 per cent. greater current for two hours with a rise not exceeding 55° C.

Three separate sources are provided for exciting the fields of the main generators, viz., the two steam driven exciters, one motor-driven exciter, and a storage battery. These are designed to give direct current at from 180 to 220 volts. The steam-driven engine units each consist of a Westinghouse-Parsons steam turbine directly coupled to a 200-kw. direct-current turbo-generator, designed to run at 1,800 r.p.m. The motor-driven exciter, also of 200-kw. capacity, is driven by a 290-h.-p., three-phase, 440-volt induction motor.

The generators are designed to run in parallel on either of two sets of main bus-bars, called the "working" and the "auxiliary" bus, only one set of which is generally in use. The switches for the outgoing feeders are arranged in groups of six, three only of each group being installed at present, being tapped from an intermediate or "group" bus. In order to distribute current to the feeders, therefore, it is first necessary to connect a group bus to either the working or the auxiliary bus, and this is done by providing each group with two selector circuit breakers, one for each of the two sets of main bus-bars. Thus, any generator, or any group of feeders, can be connected at will to either set of main bus-bars.

The system of switches, bus-bars, and auxiliary appliances is all controlled from the operating room at the east end of the third or operating gallery. This location will be opposite the center of the completed engine room when the building is extended to accommodate the final installation. This gallery is about 13 ft. above the main engine room floor, and projecting from the generating room is an overhanging observation balcony that gives a good view of the whole engine room.

A very complete system of signals for intercommunication between engine man and electrical operator has been installed, which consists of a number of illuminated signals grouped together and located at a point visible from all parts of the engine room. These are worked from the operating gallery after the engine man's attention has been obtained by means of a whistle signal. A system of return signals operated from the engine room floor and showing in the operating gallery, enables the engine man to show the electrical operator that his signals have been understood, and the two systems together supply all necessary communication between the two operating floors. A large synchroscope visible from all parts of the engine room has been installed so that by watching it the engine man is informed as the generator approaches synchronism and is switched into service.

Hoisting Machinery.—The traveling crane spanning the engine room has a capacity of 55 tons, and a span of 64 ft. It is of the double trolley type with a hoisting and a trolley motor on each trolley, besides the main motor which propels the entire crane. These motors are all operated from the 220-volt circuit. The crane was built by the Morgan Engineering Co. The hoisting trolleys are geared for both slow and rapid hoisting. Steel wire hoisting ropes are used throughout.

There are two elevators installed, one of them being a passenger elevator for serving the offices and electrical galleries, and the other a combination freight and passenger elevator in the boiler house, running from the basement to the top of the coal bin. These elevators were made by the Marine Engine & Machine Co., and are all of the electrically controlled type operated from a 220-volt circuit. They are driven by motors capable of handling live load of 1,800 lbs. at 200 ft. per minute and are fully equipped with safety devices. The elevator in the boiler house is arranged for automatic button control.

The station was planned and built by Westinghouse, Church, Kerr & Company, Engineers for the Pennsylvania, New York & Long Island Railroad Company, which is the organization through which the Pennsylvania Railroad is carrying on its New York extension work. The design and construction were under the charge of Mr. George Gibbs, Chief Engineer of Electric Traction of the road, and under the general supervision of the Mechanical & Electrical Advisory Committee—New York Extension, a committee composed of officers of the Pennsylvania Railroad Company.

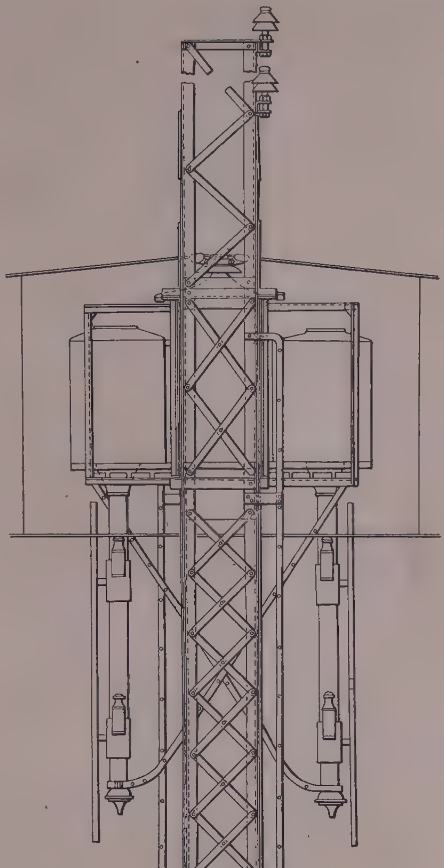
Overhead Catenary Construction for the New York, New Haven & Hartford R. R.

An account was published in The Engineering Record of March 24 of the overhead catenary construction proposed by the New York, New Haven & Hartford Railroad on its electrified section from Woodlawn to Stamford. Each trolley wire will be carried on two 5/8-in. steel catenary cables, supported by steel bridges which span four, and in some cases six, tracks. These bridges will be located every 300 ft. The trolley wires will be divided into sections about 2 miles in length by oil circuit breakers, which will be carried at these points on a bridge of heavier construction, known as an anchor bridge.

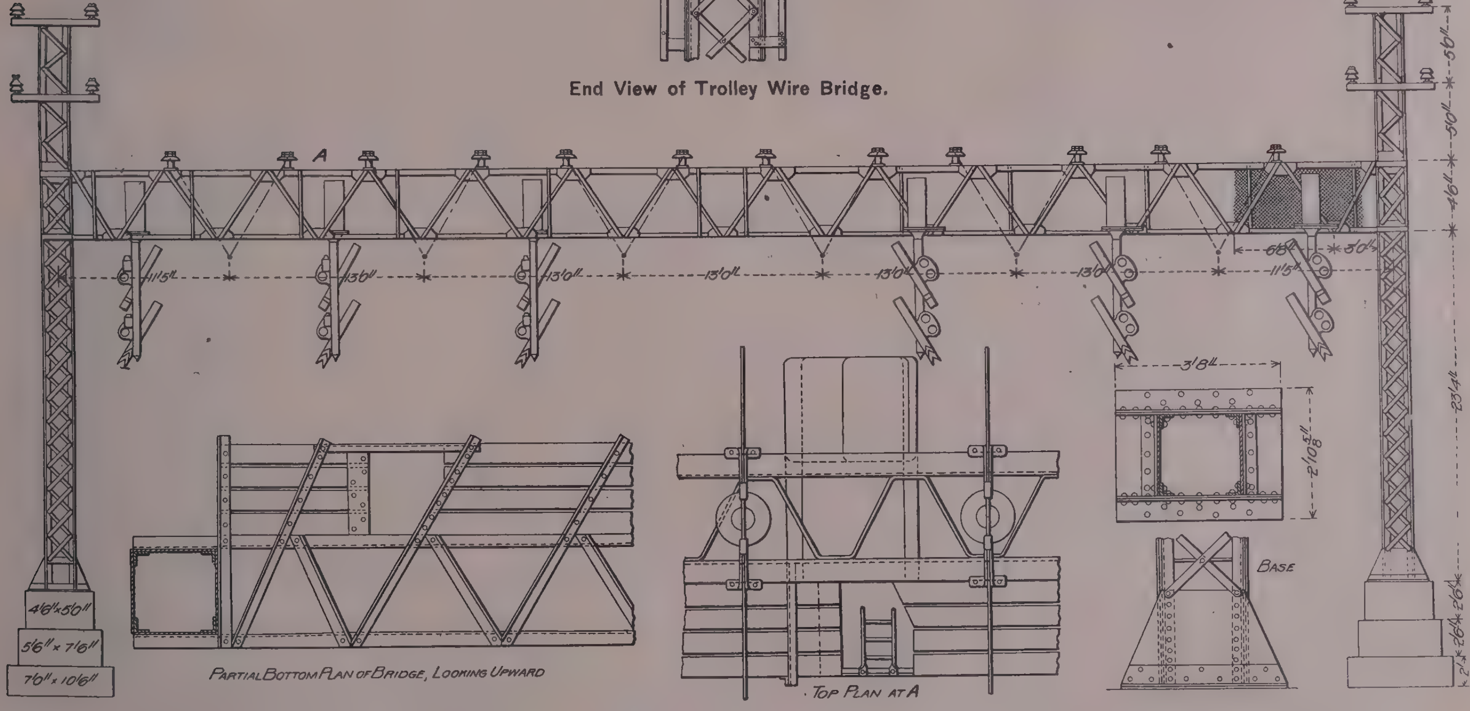
The accompanying engravings illustrate one of the intermediate bridges, designed by the Westinghouse Electric & Manufacturing Co., and intended for spanning six tracks. The posts are 87 ft. 10 in. apart on centers, 22 5/8 in. square, and are made up of four 4x9/16-in. angles with 2 1/4x 7/16-in. double lattice bars on each side. The angles of the column are riveted at the bottom to a built-up base of plates and angles, which has a bearing surface 3 ft. 3 in. long and 2 ft. 10 5/8 in. wide on the concrete pedestal, to which it is attached by four anchor bolts per column. The pedestal is 4 1/2x5 ft. at the top, 7x10 1/2 ft. at the bottom, and 7 ft. deep. The anchor bolts are carried through the entire mass of concrete to 15-in. anchor plates on its bottom surface. The columns are connected by a pair of light Warren trusses, each having a 6x4x3/4-in. angle for a top chord, and a 4x3 1/2x11/16-in. angle for a bottom chord, with angle-bar diagonals ranging in size from 3 1/2x2 1/2x3/8-in. at the ends to 2 1/2x2x5/16 in. at the center. These chord and diagonal angles are connected by gusset plates with six rivets each. The top chords of the two trusses are connected by 2 1/4x5/8-in. diagonal straps, which are riveted to the vertical faces of the angles instead of being arranged like ordinary lattice bars. The lower chords are connected by a single system of latticing, consisting of 2 1/4x2x5/16-in. angles.

Each alternate angle projects beyond the lower chord of the truss so as to carry a plank platform about 2 ft. 10 in. wide. This platform is on the opposite side of the bridge from the signals and, as the latter are on the side of the bridge facing the trains, it follows that the platform is on one side of the bridge for half the length of the latter and on the other side for the remaining distance. This platform is covered with expanded metal to protect the inspector from the high-tension lines while handling the signals. Protection against accidental contact with the catenary cables overhead is provided by a covering, also of expanded metal on planking, which is carried on 2 1/2x2x5/16-in. angles, spaced every 7 ft., and riveted to the top chord of the trusses. These angles are supported at the outer ends by uprights, which are of the same size, and 4 ft. 8 in. long, and which are riveted at their base to the platform angles.

The triangular hangers, which support the No. 0000 trolley wire from the catenaries, are spaced 10 ft. apart. They are sections of pipe and consequently hold the trolley wire rigidly to the supporting cables, but the whole structure has a spring motion on account of the flexibility of the stranded cables. All the pipe hangers are in a vertical plane at right angles to the track. The drawing does not show any circuit breakers, as these are placed only on the anchor bridges.



End View of Trolley Wire Bridge.



General Construction of Bridge to Carry Trolley Wires for Six Tracks, New York, New Haven & Hartford R. R.

The Manhattan Bridge.

The Manhattan Bridge has taken on a new lease of life. When the present administration of the Bridge Department of New York came into office, it was determined to again open the old question of eye-bars versus cables and ascertain if it would not be well to return to the former. Accordingly a public hearing was held for the purpose of giving its advocates a chance to explain its merits. None came forward, however, and so the last administration's plans for a cable suspension birdge will be carried out, unless something unforeseen arises. The bridge will unquestionably be a good one, just as an eye-bar bridge would have been a good one, provided it is properly designed and honestly erected, as will unquestionably be the case. This ought to be the last instance of delay on the structure due to differences of opinion regarding the type of suspension. The public needs the bridge too much to be kept from having it by any further attempt to settle officially an engineering subject which is a matter of deep difference of professional opinion. The public which is squeezed into jelly nightly on the old Brooklyn bridge does not care a button whether it crosses on an eye-bar bridge, a cable bridge or a bridge of sighs, if it can only be given some means of getting home which is different from the present system, by which people are packed together like sardines in a can.

Six-Stage Centrifugal Pumps of the Escher Wyss type, built by the Allis-Chalmers Co., will be used in the special fire-protection pumping stations in New York. Each will have a capacity of 3,000 gal. per minute against a head of 300 lb., and will be driven by an 800-h.-p. motor.

Cleaving Granite in the Quarry by Compressed Air.

The North Carolina Granite Corporation, of Mt. Airy, N. C., has recently commenced to use compressed air to create by cleavage working faces or ledges in the granite hillside in which its quarry is located. The property covers a gently sloping hillside of considerable extent, consisting of a perfectly solid, homogeneous mass of moderately hard granite. This stone shows no ledges or bed planes whatever, but splits readily in a straight line in almost any direction. In order to work the quarry in the most economical manner, advantage is taken of the ease with which the stone is readily split, and artificial ledges are made to which work may be carried from the surface. Large sheets or laminations of granite are separated from the hill by the combined use of powder and compressed air. The stone is then split into suitable sizes for building material, paving blocks, curbing, lintels, and stock for monumental work.

In the center of the sheet or area to be lifted, a 2 or 3-in. drill hole is sunk to a depth of 6 to 8 ft., depending on the maximum thickness of stone required. The bottom of this drill hole is enlarged into a pocket by exploding half a stick of dynamite. A small charge of powder, about a handful, is then exploded in the pocket, resulting in starting a horizontal crack or cleavage across its greater diameter. Charges increasing in size are then exploded in the cavity, the drill hole being plugged for each blast to confine the powder gases and thus exert a more or less constant force upon the stone.

After the cleavage has extended to a radius of 75 or 100 ft. in all directions from the lift hole, a pipe is cemented into the latter and connected by a globe valve to a pipe line from an air compressor. Compressed air at 70 to 80 lb. pressure is gradually admitted through this connection causing the cleavage to be rapidly extended until it comes out on the hillside in a thin edge down hill from the lift hole. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarrymen can work, thus securing from different parts of the sheet stone of any required thickness.

This method was not perfected at once, but is a gradual development of methods previously employed in the same quarry. For a number of years the practice of splitting ledges in the same manner with powder only, as followed in quarries in the Lithonia and Stone Mountain districts of Georgia, was used in this quarry. This system, however, was not entirely satisfactory. The amount of powder required is necessarily considerable, and the time required for splitting a large area of granite is quite long, since unless reasonable care is taken and time is afforded for the stone to split gradually by natural expansion and contraction, the force of the explosion brings the cleavage abruptly to the surface.

Some time ago, water under pressure was substituted for powder in the quarry after the cleavage had extended some little distance from the drill hole. This method was found to be an improvement over the use of powder only, but was surpassed in economy and convenience by using compressed air after the company installed a Sullivan air compressor last season. When the compressed air was first tried, the full pressure of 80 lb. was admitted into the cavity, which had previously been extended some 75 or 100 ft. from the lift hole in the usual manner. The power of the air was too great, however, for the character of the stone, causing the cleavage to turn abruptly to the surface. A new drill hole was sunk in another part of the quarry, and the cleavage started by powder in the same manner as before. The compressed air pipe was then attached again and the air admitted very gradually. The stone could soon be heard cracking in all directions and in about half an hour the cleavage came to the surface on the hillside some 225 ft. down-hill from the lift hole. The time required for extending the cleavage by powder for 100 ft. was between two and three weeks, while to split a larger area to the radius of 225 ft. required only half an hour when compressed air was used.

Only a portion of the cleavage extended to the surface, owing to the thickness of the sheet on the up-hill portion of the slope. The ledge or bed plane thus formed was reached by quarry bars and drills in the usual manner. It is believed that this is the only quarry where compressed air is used to split granite in this manner, and it can readily be seen that the method affords a great saving of time and expense

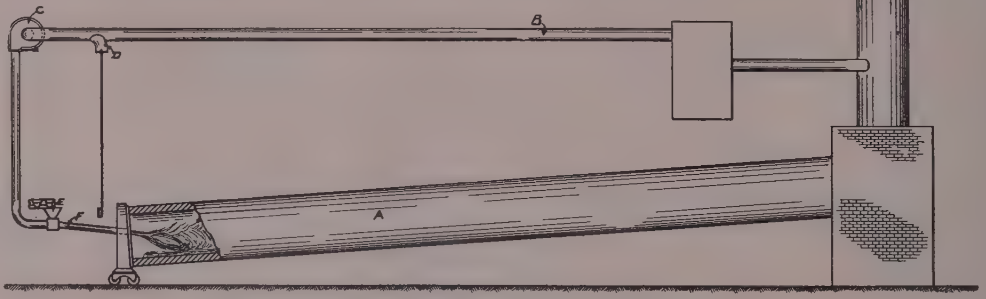
The granite for many building and paving purposes is produced by this and other economical methods of operation at a price comparing favorably with the cost of production in any quarry in the country. The equipment of the quarry is modern in every respect, including 35 plug drills, 3 Sullivan tripod drills, 4 Sullivan quarry bars, 15 surfacing machines and 60 small hand tools. These are all operated by air power from a Sullivan-Corliss air compressor, furnished by the Sullivan Machinery Co., of Chicago.

This compressor is of the two-stage type, with a piston displacement of 2,000 cu. ft. of free air per minute at 78 r.p.m. against 80 to 100 lb. terminal pressure. The steam cylinders of the compressor are 16 and 28x42-in., and the air cylinders 16 and 26x42 in. Semi-rotary or Corliss air inlet valves are used, directly actuated by separate eccentrics on the engine shaft. They are of relatively large diameter and remain open during the entire stroke, but close very quickly. The poppet air discharge valves are in the cylinder heads, and act in a direction parallel with the piston rod. The air supply is drawn from outside the engine room insuring colder, cleaner and drier air. The air cylinders and cylinder heads are water-jacketed, and there is a large receiver intercooler between the high and low-pressure air cylinders. The steam end is a Sullivan heavy-duty Corliss cross-compound condensing engine, to the rear of which the air cylinders are coupled in tandem. All cylinders, both steam and air, are made with loose liners, forced into the cylinder castings by hydraulic pressure. A steam receiver and reheater is situated between the high and low-pressure steam cylinders, below the floor line.

The quarried stone is handled from the quarry to a 65x360-ft. cutting shed, or to cars on a railroad track, by nine cableways. An incline is also provided for loading rough stone for shipment. A 20-ton Pawling & Harnischfeger electric crane, with a 5-ton auxiliary hoist, is used to handle stock in the cutting shed. The boiler and engine house is 53x112 ft. in plan. It contains the air compressor mentioned, two Heine 210-h.-p. water-tube boilers, a 150-h.-p. Ideal compound engine, coupled direct to a 100-kw Bullock generator.

The New Kiln Firing Process at the Lawrence Cement Co.'s Siegfried Mill.

Manufacturers of Portland cement have known for some time that a new kiln firing process has been introduced with marked success at the works of the Lawrence Cement Co., at Siegfried, Pa., and the purpose of this article is to furnish information concerning the method, obtained during a recent visit to the plant. The principle on which it rests has been used extensively in lime burning, and is covered by a number of patents, the first being one granted to Mr. Byron E. Eldred four years ago. It depends primarily upon the modification of a flame by mingling a neutral diluent with the air which supports combustion. In this way the temperature and volume of the flame and the duration of combustion can be altered greatly. The flame can be cooled so that it will not ignite wood placed in its path, or it can be raised so as to melt firebrick. Moreover, the flame can be kept under very close control without adding to the amount of supervision required by the usual methods.

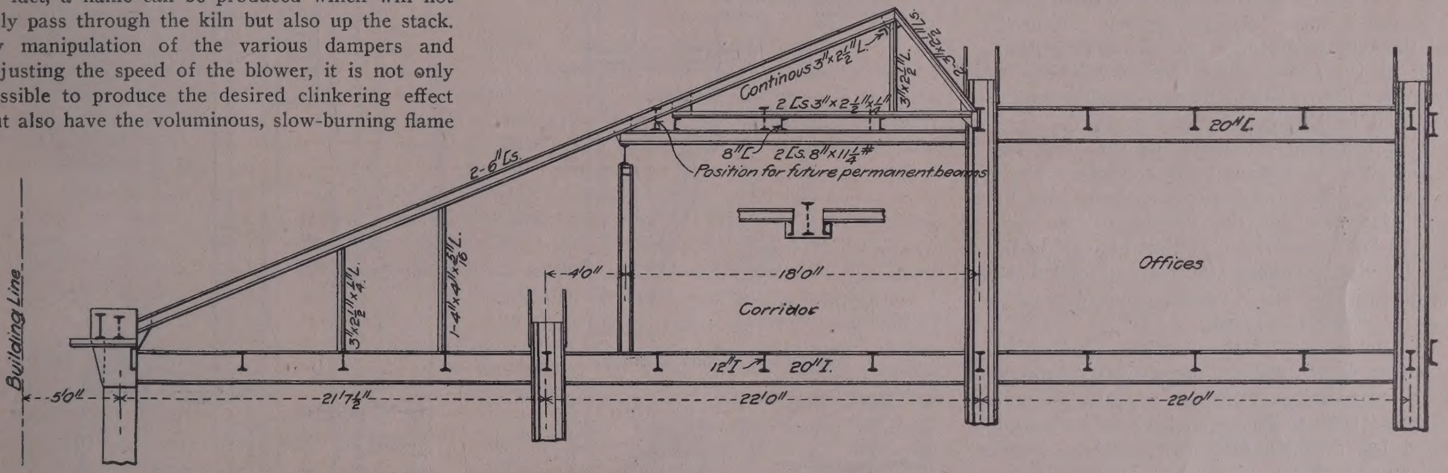


New Firing System Used by the Lawrence Cement Co.

In burning lime and cement, annealing and heating steel and many other industrial processes involving high temperatures, the methods of combustion best suited to steam boilers require modification, although this fact was long overlooked. In such processes air contains too much oxygen for the kind of flame required. A number of attempts to produce a flame of low temperature and large volume have been made in the past, such as those using steam as a diluent, but they have proved either impracticable or uneconomical. It has frequently been proposed to return part or all of the gases of combustion to the firebox in order to save in some way the heat they contain, but these suggestions have been failures on account of the great volume of the returned gases, and the lack of comprehension of their true effect on the fire. The Eldred process as worked out for lime burning is of interest as the forerunner of the kiln practice now followed by the Lawrence Cement Co., and is substantially as follows: A flue is tapped into the shaft of the kiln high enough to secure gases of fairly uniform quality and is led to a blower. At one portion of its length there is an air inlet with an adjustable damper at its mouth. The blower has two outlets, one under the grate and the other into the open air. This arrangement makes it possible to draw air and gases through the blower in any desired proportion, by adjusting the air inlet valve. By adjusting the damper of the free discharge opening and changing the speed of the blower, the pressure and volume of the blast under the grate can be modified through a wide range. When the apparatus is properly adjusted the combined effect of the blast and the diluent is to evolve the heat of the fuel where it is most needed, instead of at the portion of the kiln where it occurs under natural conditions. The temperature of the furnace and fuel bed is lowered and that of the charge is more uniformly distributed than with a pure air draft. As a result the output of an ordinary kiln is materially raised, as much as 50 per cent. in some cases, and the amount of fuel is cut down, while the quality of the lime is either unchanged or improved.

This method of controlling combustion has an immediate application in processes where the slow-burning gases have a considerable travel in a region of high heat, so that they are not chilled before complete combustion has occurred. A rotary cement kiln is particularly adapted for its use on this account, and Mr. Eldred has patented a modification of it for cement burning. The rotary kiln is acknowledged to be wasteful of fuel, but this defect is more than counterbalanced by its large output under skillful supervision. The powdered coal blown into the kiln burns with an intense heat, and if the flame deflects much from an axial line there is a tendency for the material to form rings and even for the lining to deteriorate very rapidly. Consequently the region of maximum heat is along the center line of kiln and not directly on the material at the clinkering zone.

By mixing some of the waste gases from the stack of the kiln with air blast for the powdered coal it becomes possible to produce a flame of such a temperature that it can be directed immediately on the material and will have its maximum temperature in the clinkering zone. In fact, a flame can be produced which will not only pass through the kiln but also up the stack. By manipulation of the various dampers and adjusting the speed of the blower, it is not only possible to produce the desired clinkering effect but also have the voluminous, slow-burning flame desirable for calcining the charge before it begins to clinker. It is occasionally stated that undercalcination is desirable in order to make the clinker grind easily, but it is important to bear in mind that such material requires a large amount of heat to clinker, owing to the chilling effect of the unremoved carbon dioxide it contains.



Part of Temporary Roof over Fifth Office Story.

The accompanying diagram indicates roughly the nature of the apparatus used at the mill of the Lawrence Cement Co. There are eight kilns, all using the Eldred process. The gases are taken from two of the stacks into a mixing chamber, from which a duct runs to the two blowers, *C*, of which but one is operated. These are located just under the roof, where there was more room for them than at any other place. The duct has an air opening, *D*, and by adjusting its damper and those on the waste-gas flues the desired mixture of air and gas is produced. This blast is used like that when pure air is employed, but the nozzles inside the kiln have been specially designed. Although the plant has an enviable reputation for high capacity and low fuel costs, the use of this method of firing has increased its output per kiln about 8 per cent. and decreased the fuel consumption about 5 per cent., without causing any change whatever in the quality of the product. It is not unlikely that with greater experience, these results will be surpassed. The installation was made by the Combustion Utilities Co., of New York.

Steelwork Details of the New Office Building of the New York Central R. R.

The post-office floor of the office building the New York Central R. R. is erecting in New York (see Engineering Record, Feb. 24 and March 17), is about 3 ft. above street level at Depew Place, so as to form there a platform of convenient height for loading and unloading mail wagons. At Lexington Ave. it is about 18 ft. above the sidewalk level. It extends from Depew Place to within four panels, or about 90 ft., of the 45th St. front where it is dropped about 10 ft. to the level of the 45th St. viaduct floor. Here it forms the floor of the general delivery post office, which, like the main post office, extends to the first office floor but is a much higher room. The floor construction consists mainly of longitudinal 15-in. 42-lb. I-beams about 5½ ft. apart, which are supported on transverse plate girders of 44-ft. span, 20 ft. 9 in. apart. These girders are 38 in. deep with 7/16-in., web plates, four 6x6x⅝-in. flange angles and four 14x½ in. flange cover plates 21 ft. and 32 ft. long. They are made without intermediate web-stiffener angles and are connected by brackets to the main columns. This detail is adopted throughout the building for all girders, because web connections would involve objectionable through bolts in the closed box columns.

One longitudinal panel 44 ft. wide is spanned by transverse lattice girders which are used instead of plate girders to allow longitudinal pipe lines to be run through them without difficulty. These girders are 7 ft. 9 in. deep and have top and bottom chords made of pairs of 6x4-in. and 6x6-in. angles, respectively, reinforced in the three center panels with a 14x7/16-in. web plate. The girder is divided into nine unequal panels by zigzag diagonal pairs of 5x3½-in. and 6x4-in. angles. The post office floor is carried by the longitudinal 15-in. I-beams flush with its top flanges and web-connected to two pairs of vertical angles at the panel points, extending from the top to the bottom flanges. The girders are somewhat unsymmetrical and are proportioned for maximum stresses of 215,000 lb. in the top and bottom flanges.

At the level of this floor there is in the three longitudinal panels of the Lexington Ave. front nearest the 45th St. end of the building a platform 7 ft. wide and about 62 ft. long, with its center line nearly in the plane of the wall columns, which is intended to carry a load of about 2,000,000 lb., most of which is due to the enormous weight of a group of solid granite columns about 7 ft. in diameter and 60 ft. high forming part of the decoration for the front of the building. This platform consists of six lines of 20-in., 80-lb. I-beams, each calculated for a reaction of 53,000 lb. at each end. They are supported, as indicated in the detail, by direct connection to the main wall column and regular transverse girders and by special exterior columns continued up from the Lexington Ave. floor and terminating at this level.

In the four transverse rows nearest the 45th St. front, there begins at the level of this floor a series of columns before mentioned which are in longitudinal rows 44 ft. apart intermediate between the main columns. In the outer row, these columns carry maximum loads of 1,474,200 lb. and have a rectangular cross-section made of four 4x4x⅝-in. angles, two 18x5-in. web plates and six 20x⅝-in. cover plates. They are seated directly on twin plate girders 7 ft. deep, previously described, and have special bases designed to distribute the load equally over both girders. These bases are field riveted to the column, to which they are connected with milled butt joints and splice plates.

It is assumed that the entire column load is transferred to the girders through the wing plates of the extended base, and in order to secure sufficient rivets to carry the load from the flange angles and web plates it was necessary to add the inside vertical distributing angles indicated by dotted lines. This type of column base was at one time considered for the bearings of the main columns on a foundation grillage, but was abandoned for this purpose because of the assurance from prominent steel contractors that the tapered columns already described would be cheaper than those having detached bases and that the bases would be difficult to build and almost impossible to face accurately.

In the Depew Place front of the building many of the columns are enclosed at the post office floor level by horizontal octagonal shelves made of ½ in. cap plates to form a support for the granite piers surrounding the steel columns, as indicated in the detail plan and elevation. Each shelf is supported by eight solid web kneebraces with 4x4-in. vertical and horizontal connection angles and ⅜-in. gusset plates.

The lower portion of the building, which is treated architecturally as a base, terminates in a very heavy cornice at the fourth office floor, at which level the faces of the upper parts of the walls are set back about 3 ft. On the Depew Place side it was impossible on account of the track spacing to set the columns far enough back from the building line to be contained in the thickness in the upper wall, as was done in the remaining sides. Each of these columns was therefore made in two lines, both placed in the thickness of the wall. The lower lines terminate at the fourth office floor and support on their caps the ends of heavy transverse girders, one panel long, which are carried at the opposite ends on the main interior columns which also support the heavy trusses. The upper lines of the wall columns are seated on the top flanges of these girders which enable them to be offset at the required distance from the center of the lower lines. The girders carrying the columns are 36 in. deep and 23 ft. long, with 7/16-in. webs reinforced by two ⅜-in. plates planed to fit the flange angle fillets and two ½-in. fillers 5 ft. long between the column bearings. They have four 6x6x½-in. flange angles and two 14x½-in. flange cover plates 14 ft. long. There are four pairs of 5x3½x½-in. web stiffener angles under the columns.

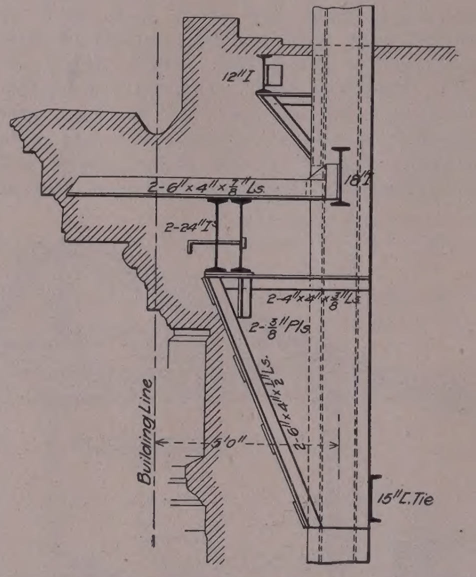
In order to diminish the long spans of floor girders necessary in the lower stories on account of the location of the longitudinal column rows 44 ft. apart to provide clearance for three tracks between them, the main columns are connected between the third and fourth office floors by a series of heavy riveted trusses in transverse planes, which, at their center points, carry subcolumns reaching from the fourth office floor to the roof. These trusses are uniformly 44 ft. long over all, 12 ft. 7 in. deep and 20 ft. 9 in. apart on centers. Each is made of three triangular panels formed by the inclined end posts and the center diagonals, and the ends of their lower chords abut and are riveted together on the center lines of the columns, where they are supported by bearing on the caps of the outer webs, which terminate here, of the three-web columns, the inner webs being continuous above this point. This detail, like the similar one already described for the support of the 7-in. twin girders in the outer wall at the level of the 45th St. viaduct, affords the truss a solid direct bearing without involving any riveted connections or eccentric stresses.

The trusses are of the simplest construction, having top chords and end posts with open rectangular cross-sections made up of pairs of built channels about 16 in. apart, back to back, connected by tranverse diaphragms and by lattice bars and tie plates on top and bottom flanges. They are joined together at the panel points by gusset plates which serve as jaws for the connection to the diagonal members. The maximum stresses are 790,000 lb. in the top chords, 685,000 lb. in the inclined end posts and 400,000 lb. in the bottom chords. The top chords are made of four 6x4x11/16-in. flange angles, four 20x⅜-in. web plates and two 8x⅝-in. fillers. The bottom chords are made of four 6x4x11/16-in. flange angles and two 20x11/16-in. web plates. The distance between the web plates in the top and bottom chords affords clearance for the intermediate columns, which, in reality, pass through the top chord, and, continuing across the truss, form center vertical posts connected at the feet to the lower chords.

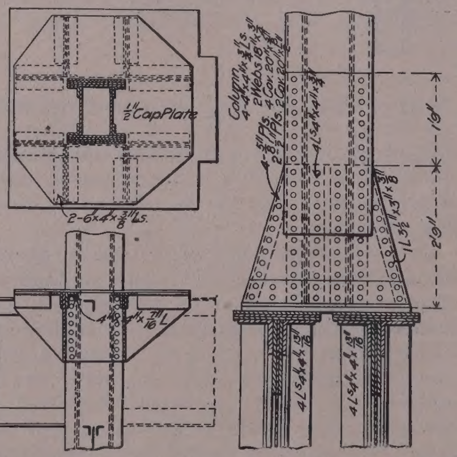
The top chords of the trusses carry, and are flush with the 12-in. 31½-lb. I-beams 5½ ft. apart which carry the fourth office floor. The lower chords carry similar I-beams in the same vertical planes which support the floor of the pipe gallery. This is a story 12 ft. 10 in. high, intermediate between the third and fourth office floors, and is enclosed by the solid walls of the main cornice.

In the absence of available basement space this story was primarily designed for the distribution of pipes, mains and conduits in a horizontal direction, so that vertical lines and branches could be run from them as required. As this service does not require light from the exterior the architectural features were made in accordance, and opportunity was afforded here for the deep and heavy stone cornice which occupies the height of this story and precludes the location of windows there. This construction is evidently more expensive than some other method but was considered justifiable on account of the reasons above explained and because it will eventually result in a considerable economy when the building is entended to its full height. The present design contemplates the lighting of the interior of the pipe gallery story by windows in the center courts. This arrangement will afford considerable available space in a belt surrounding each light court which can be used for telephone exchange and shops. This area may therefore be enclosed and used for various purposes while the outer space is devoted to the pipe distribution as above explained.

The main cornice at the level of the fourth office floor is built of large cut stones and has a maximum projection of nearly 9 ft. beyond the centers of the columns. This produces a very heavy eccentric load which is supported, as shown in the cross-sectional detail, by a pair of 24-in. 80-lb. I-beams seated on solid-web knee-brace brackets riveted to the column flanges. These beams serve as fulcrums for pairs of 6x4-in. angles about 8 ft. long, which are riveted together back to back and have their horizontal flanges seated on the top flanges of the beams. Their inner ends are riveted to gusset plates with web connections to 18-in. 55-lb. I-beams on the center lines of the wall columns which serve as anchorages. The cantilever angles are about 3 ft. apart and support the upper part of the cornice, while the lower portion of it is secured by hook bolts passing through the webs of the I-beams.

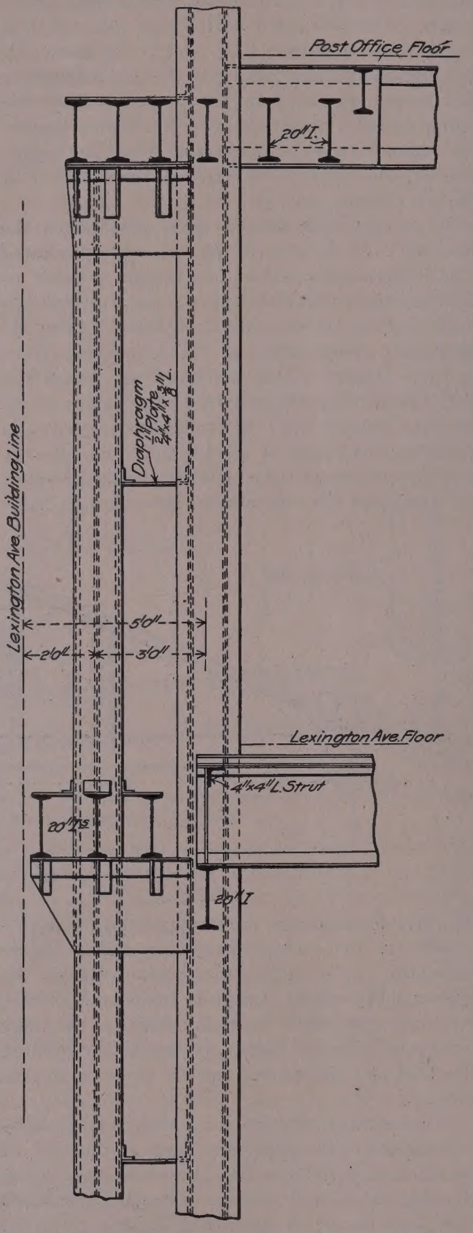


Support of Stone Cornice.



Girder Support for Intermediate Column at Post Office Floor.

The first office floor steelwork is special in that it has 46-in. transverse girders 44 ft. long which carry at their center points intermediate two-story columns terminating at the third office floor. These girders are made of 9/16-in. web plates, four 6x6x11/16-in. angles, and six 14-in. flange cover plates. Connected to the girders by brackets are the 12-in. 31½-lb. longitudinal I-beams 5½ ft. apart which carry the concrete floor slabs. This construction was adopted for economy, in order to make the second and third office floors as thin as possible, and because the extension of the deep girders below the ceiling of the railroad post office in the story below is unobjectionable. The light wells commence at the level of this floor, where they are closed by a skylight supported on riveted longitudinal lattice girder trusses of 62-ft. span 22 ft. apart, forming a hipped roof with a monitor. The second and third floors are of simple construction with regular rectangular panels made of 20-in. 80-lb. longitudinal I-beams 22 ft. long, carrying 12-in. transverse beams about 5 ft. apart, on which the concrete floor slabs are constructed.



Wall Girders Supporting Heavy Stone Columns.

The fifth office floor is typical of all those above the fourth and corresponds essentially to the second and third floors, being made of 20-in. 80-lb. longitudinal I-beam girders carrying 12-in. 35-lb. transverse I-beams 5½ ft. apart.

The temporary roof is a comparatively light flat structure pitched slightly except on the outer edges and supported by the tiers of beams and girders intended eventually to serve for the sixth office floor. For that portion of the building now being built there is a copper covered roof 44 ft. wide, pitched about 1:3 which forms three sides of a rectangle and extends around the principal street fronts of the building. From its ridges short, steep, copper slopes extend in the opposite direction towards the interior court and intersect a flat sloping roof which covers the remainder of the area and is divided into hips and valleys for drainage with flat slopes. The flat roof surface is covered by cinder concrete filling over the concrete slabs forming the office floor. This filling has a maximum thickness of nearly 2 ft. The copper roof sheathing is laid directly on concrete slabs supported by trussed 6 in. and 8-in. purlin channels, and 20-in. 80-lb. I-beam girders. The concrete roof slabs are carried by 12-in. 35-lb. I-beams 5½ ft. apart on 20-in. 80-lb. girders.

Special pains were taken in the construction of this roof to design it so that it can be removed and the erection of the upper stories of the building can be accomplished without any interference whatever with the interior offices or corridors. To this end all of the columns are carried above the floor line and are provided at their upper ends with splice plates ready to receive the footings of the columns in the upper stories. There are no offices in the fifth story between the corridor and the outer walls, therefore the removal of the temporary roof over that portion of the structure will not interfere with any tenants and a ceiling over the corridor will serve as a temporary roof. After the pitched roof is removed the final transverse girders to carry the next floor can be placed over it, alternating with the present light girders and cantilever beyond the one-story struts now carrying the latter. This will enable the columns to be extended and the construction to proceed above and around the corridor without entering the latter, as is evident from the cross-section of a part of the roof framing. The copper sheathing of the roof is continued at the eaves to line the deep gutter moulded in the concrete which covers the back and upper part of the light cornice.

Messrs. Reed & Stem and Messrs. Warren & Wetmore are associated as architects for this building, the steelwork and structural details being under the charge of Mr. H. G. Balcom. The John Pierce Co. is the general contractor and the steelwork has been awarded to the McClintic-Marshall Co.

Book Notes.

The accounting side of public service undertakings is one of the most important executive departments, and yet very little has been published concerning it. For this reason, Messrs. John H. Brearley and Benjamin Taylor's "Gas Companies Bookkeeping" will probably appeal to a circle of readers much wider than the officers and employees of gas companies. While it discusses the subject from a British point of view, there is, of course, nothing national in the principles of correct bookkeeping and auditing, and what is best in one country is likely to be best in another, conditions being the same. The book explains the methods of entering the financial accounts, purchases, sales, costs, stocks and other items, and gives complete examples of each. A very interesting feature is a diagram showing the relation of the various books and accounts, which might be consulted with advantage by people who are engaged in adopting or remodeling an accounting system. (London, Walter King; cloth, $4 delivered in U. S.).

A book that will be welcome to the building contractor and architect is Prof. Henry Adams' "Building Construction." It is a profusely illustrated volume of about 550 pages, well indexed and arranged for ready reference. The properties of structural materials are explained at some length and the details of construction are treated concisely but well, the free use of illustrations permitting a brevity in the text which deserves special commendation. Plumbing, heating and similar topics, concerning which specialists should be consulted when the work exceeds a moderate size, very properly receive less detailed attention than the chapters on structural details. The theory of roof trusses, beams, girders, posts, columns, arched ribs, walls and other details is explained with the author's well-known lucidity, and, except for a superfluous chapter on bridges, there is nothing to criticise adversely in the whole book. Special approval should be given to the illustrations, which are prepared in conformity with a system of conventional markings for the chief building materials, so that in many cases a single drawing will convey more information than could be crammed in a couple of pages of text. (London, Cassell & Co.).

Yards and Terminals and Their Operation. By J. A. Droege. New York, The Railroad Gazette; cloth, 8vo., 285 pp., $2.50.

It is gratifying to record the appearance of a good book by a competent author on a techincal subject that has not previously been covered. Probably yards and terminals have had less written concerning them than any other branch of railway civil engineering, although they are of the highest importance; there is no other book which treats of them exclusively and the articles concerning yards and terminals are almost exclusively descriptions of single installations.

The book opens with a general discussion of the relative importance of terminals and an explanation of the terms and definitions concerning them. The general principles of yard and terminal arrangement are then discussed and the designing of terminals is explained. Then follow chapters on details, track, ash track, coaling plants and icing plants. The general methods of switching are next explained, followed by detailed discussions of pole, summit and gravity switching. The chapters on records, management and discipline, and the yardmaster's duties are of less direct engineering interest than the others in the book, but are useful as explaining the operation of yards and terminals. The description of the methods of loading cars and making up trains is particularly instructive to students of railway affairs, and there are some suggestions in them which deserve to be discussed at length by other officials, as there is a greater difference of opinion regarding them than might be inferred from the text. The problem of handling fast freight is explained well and its importance and the trouble it causes are pointed out clearly. The descriptions of freight houses, freight piers and coal piers are satisfactory.

The present time is one in which railway yards and terminals are receiving special attention, and for this reason the book is timely. Main line improvements have been carried out which have given our roads a greater carrying than terminal capacity, and when the revival of traffic began a few years ago operating officials found themselves tied up in bow knots by inability to get freight through the yards of the larger cities and into the terminals. Even a road so far-sighted as the Pennsylvania was badly crippled at Pittsburg and at Jersey City, and is apparently destined to be at Baltimore, through insufficient facilities for getting freight through or arond the yards.

Letters to the Editor.

Pile Driving.

Sir: My attention was called to your editorial on pile driving in the issue of The Engineering Record of March 24. I have not seen the paper on over-driven piles in your issue of Feb. 17, but in reading your editorial carefully, I am impressed with the number of points which you make in regard to over-driven piles and the so-called "driving to refusal," which are borne out by my experience covering a period of over 30 years in contract work, of which pile driving, under many different conditions, has formed no little part. Pile driving, like the practice of medicine, is not an exact science, and the formulas by which the safe load a pile will carry are worked out are unreliable and absolutely unsafe unless a large amount of practical experience lies back of all the conclusions based on them. The conditions are so changeable and unreliable as regards the tenacity of the soil, the probable friction between the pile and the soil, the nature of the wood in the pile, etc., that it is utterly impossible to express in figures what a given pile will hold.

A great many years ago, even before the advent of the friction drum on hoisting engines, it was necessary to drive a short trestle on a railroad over a very deep marsh, and it was thought necessary at first by the engineer to get to hard bottom. A pile 35 ft. long was driven, and to this was spliced another of about the same length, which was also driven, and still no bottom was found, and the pile seemed to go about 4 or 5 in. to a blow. After this, the next pile was started and driven into the mud perhaps 25 ft. It was then quitting time, so the pile was left standing in the ways until the next morning, when the driving was commenced again; it was struck five or six blows, and no appreciable movement was discovered, and as this was in the days of hammer-tongs and man power, the results were encouraging enough to send for the engineer in charge. It did not take any further argument to convince him that the friction and the set of the material on the pile would be sufficient to carry any loads which the roads would run over this trestle. The consequence was that the piles were driven about 35 or 40 ft. in length through soft meadow muck, and not one of them touches the so-called hard bottom. This foundation has been carrying much heavier cars and locomotives for years than it was originally thought would ever be used on it.

Upon another contract, in more recent years, the engineer defined in his specifications what he called "driving to a refusal." He required the piles to be of a certain diameter at the butt, and being fearful that he would not get wood enough, required that they should "hold their size." Owing to the peculiar nature of the soil in which they were to be driven, they were driven "to refusal" before they had been struck five or six blows. The effect was about the same as trying to drive with an ordinary pile driver a pile but slightly smaller than a flour barrel into a sand beach. After considerable argument, he was persuaded that these large piles could not be driven, and that he would get better results by cutting out the scientific formula and using a greater number of smaller piles in a practical manner.

On another occasion, in putting the foundations under one of the most important railroad bridges in the country, I had occasion to call attention to the excess driving that was required by the under engineers. Many of them are older now, and their own experience would teach them to handle matters differently. There was a formula and the piles were to be driven "to refusal."

The piles were tough, the engines were new and powerful, the engineers directly in charge were just out of college for their first season on the road, the foremen were old experienced pile drivers, the bottom was sandy with some gravel, and as I look back upon this experience after a lapse of more than 20 years "it is to laugh," although, at the time, I certainly did not feel that it was a laughing matter to strike piles six and seven hundred blows. The heads were hot and crumbled, and many of them were broken once, and some of them twice, but the orders were to continue driving. On this point there could be no "refusal." The bridge foundation stands all right to this day, but I do not attribute it to the fact that these piles were driven to the so-called "refusal."

There is more practical common sense and knowledge in your article on pile driving than I have ever seen in all the engineering works put together. You have covered the whole ground in less than two columns, and told what every practical man knows. Many engineers undertake to tell, theoretically, in pages, what no one can know, except through actual experience.

Very truly yours, FRANK PIDGEON.
Saugerties, N. Y.

PROBLEMS IN RAILWAY CURVES.

SIR: I hand you herewith what seems to be a solution of the problem submitted by Subscriber on page 410 of the issue of your paper for March 24. *AB*, *BC*, *AD*, *EC* and the angle *ABC* in Fig. 1 are known. Calculate all angles and sides of the triangle *ABD*. Calculate all angles and sides of triangle *BCE*. For the angle *EBD*, add the calculated angles *ABD* and *EBC* and deduct the sum from the measured angle *ABC*. Knowing the angle *EBD* and the two sides *BD* and *BE*, the other sides and angles of this triangle can be calculated. The distance *FG* will be the difference between the radii *AD* and *EC* plus the distance *DE*. The arc *AG* can be computed from the sum of the angles *ADB* and *BDG* and the arc *CF* from the difference of the angles *ABC* and *ADG*.

Yours very truly, R. M. CLAYTON.
Atlanta, Ga.

SIR: Enclosed please find a solution for the problem in railway curves presented in The Engineering Record of March 24. In Fig. 2, R, r, AC, BC and the intersection angle at C are known, and the problem is to find the arcs AE and BD, and the distance DE. Extend the curve of radius R to a tangent parallel with BC. AH will then equal hH and also R times the tangent of half the angle at C. Ch will equal $Ah - AC$; $ih = IH = Ch$ times the sine of the intersection angle C. $Ci = Ch \cos C$. $BI = Hh \pm iC - BC$; use + when $C = 90° +$ and — when $C = 90° -$. $KL = R - (r + IH)$. $\tan x = BI/KL$; $y = C - x$. From a table of circular arcs find constants for x and y, and multiply them by r and R respectively to obtain the desired arcs. $DE = R - (r + KL \sec x)$.

I also wish to request a solution of a problem. In Fig. 3, d, r, R and the angle A are given, and x is sought.

Very truly yours, WM. R. DUNHAM, JR.
Providence, R. I.

SIR: The following solution of the problem presented by Subscriber in your issue of March 24 is submitted. In Fig. 4, given *AC*, *CB*, *R*, *r* and the angle *ACB*, it is required to find *AE*, *DB* and *ED*.

The line *EK*, being tangent to both curves *AE* and *DB* will pass through their centers. Project *AK* and *CB* to *H*, forming the right triangle *HCA* in which *AC* and angle *ACH* are known and sides *AH* and *CH* and angle *CHA* can be computed. The known distances *CB* and *AK*, subtracted from the computed sides *CH* and *AH*, will give the sides *BH* and *KH* of the oblique triangle *BKH*. Having computed the two sides and the included angle of this triangle, the remaining angles and side can be computed by the laws of tangents and sines. In the oblique triangle *KBM* the side *BM* or *r* is known, the side *KB* has been computed and the angle *MBK* is equal to 90° minus the computed angle *KBH* from which the other side and angles can be computed. The distance *DE* is equal to $R - (r + MK)$. The angle $AKE = 180° - (\text{angle } HKB + \text{angle } BKM)$. The angle $BME = 180° - \text{angle } KMB$. Knowing the angles *AKE* and *BME* and the radii *R* and *r*, the length of the curves can be computed.

Respectfully submitted, EMIL L. NUEBLING.
Reading, Pa.

SIR: Replying to your proposition on page 410 of your issue of March 24, 1906, concerning railway curves, I attach hereto a detailed solution of this problem, which appears to me to be a practicable one. This proposition can readily be simplified by the aid of the scale and the protractor. In Fig. 5 given *I*, the semitangents *AB* and *BC*, the radius *R* and the small radius *r*; to find the length of curves and the offset between parallel tangents to those curves. Let *AB* and *BC* be tangent to those curves at *A* and *C*. At *A* erect a perpendicular to *AB* equal to *r*. At *C* erect a perpendicular to *BC* equal to *R*. Through *D* and *G* draw a line meeting the outer curve at *F*. Now the angles *D* and *AGE* and the line *EF* can readily be scaled.

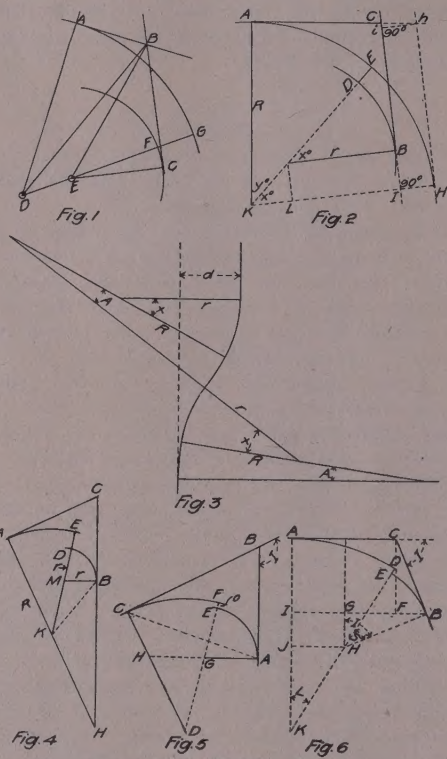


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6

Problems in Railway Curves.

The proposition can also be calculated in the following manner: Given the data as above. Draw the line *AC* and produce *AG* to *H*, forming the triangles *ACB*, *ACH*, and *HDG*. The solution of these will determine the central angles, or the lengths of the curves and also the offset *EF*.

First. In the triangle *ABC* we have two sides, *AB* and *BC* and the included angle *B* whence by the well known formulas:

$$\tan \tfrac{1}{2}(A - C) = [(a - c) / (a + c)] \tan \tfrac{1}{2}(A + C)$$

and

$$AC/BC = \sin B / \sin A,$$

we can readily find the angles *ACB* and *BAC*, and side *AC*.

Second. $ACH = 90° - BCA$; $CAH = 90° - BAC$. Solving the triangle *ACH* we have *AH*, *CH* and the angle *CHA*.

Third. Solving the triangle *DHG*, we find the angle *D* and side *DG*. The angle $FGA = I - \text{angle } D$, and $EF = R - (DG + r) = \text{offset}$.

Yours respectfully, C. M. ESTABROOK.
Cumberland, Md.

SIR: Enclosed is a solution of the problem given in The Engineering Record of March 24, 1906. In Fig. 6, let $AK = R$, $BH = r$, $CB = T_r$ and $AC = T_R$. Given R, r, T_R, T_r and the angle I, to find the lengths of the arcs AD and BE.

From the difference in the proper elevation of the outer rail for the two curves determine the length of the easement curve. Take from Allen's "Field and Office Tables" the spiral of this length and for the degree of curve equal to the difference between the degrees of the curves *AD* and *BE*, as the easement curve. The value of *p* given for this spiral is the value for $DE = O$.

In Fig. 6, $K = KH \cos L = (R - r - O) \cos L = AK - (CF + GH)$. $CF = T_r \sin I$. $GH = r \cos I$. $\cos L = (R - T_r \sin I - r \cos I) \div (R - r - O)$. From this equation L may be found. $S = I - L$. From the degrees of the curves AD and BE and the central angles L and S, the lengths of AD and BE may be found.

Yours very truly, E. R. CARY.
Troy, March 27.

[The above letters are types of solutions submitted by many readers. Some of the modifications of the above typical solutions are quite ingenious but it is hardly necessary to print them here. Attention is called to the new problem propounded by Mr. Dunham.]

STRIKING CENTERS ON THE DANVILLE ARCH.

SIR: I note in The Engineering Record of March 3 a very interesting article on the construction of the Danville Bridge. The article is a good one, but there is a part of it which I cannot understand; that is, the construction of the arcade or spandrel arches which rest on the extradoses of the three main arches. I would like to know just exactly at what stage of the construction the centers were lowered, and also when they were completely dismantled. Were the main arches lowered before the spandrel arches were built? Was this done in some cases and not in others? Any data relative to this will be greatly appreciated by me.

Very respectfully, W. J. DOUGLAS.
Washington, D. C.

SIR: In response to the question of your correspondent with reference to the stage of construction at which the arches of the Danville Bridge were lowered, I beg to advise the following:

The centering for the 100-ft. and two 80-ft. spans was kept in place and held tight by means of wedges, until the first three spandrel arches adjacent to the pilaster walls over the 100-ft. arch and the first two spandrel arches adjacent to the pilaster walls over the 80-ft. arches were constructed. The centers were then loosened and the remainder of the spandrel arches were constructed. At the time the centers were loosened, no settlement at the crown of the 100 or the 80-ft. spans could be detected by careful instrumental observation. The coping was constructed subsequent to the completion of all the spandrel arches.

Yours truly, F. W. SMITH.
Mt. Carmel, Ill.